Report of the

TWENTY-EIGHTH SOUTHERN PASTURE AND FORAGE CROP IMPROVEMENT CONFERENCE

Oklahoma State University
Stillwater, Oklahoma 74074

July 6-8, 1971

AND

Contributed Papers of Work Groups Meeting
in Conjunction with SPFCIC
July 6, 1971

Southern Forage Breeders' Group
Southern Forage Physiology and Ecology Work Group
Southern Forage Extension Work Group

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service
Plant Science Research Division

PSR-47-71

TABLE OF CONTENTS

Page

SOUTHERN PASTURE AND FORAGE CROP IMPROVEMENT CONFERENCE, July 7, 1971.. 1

Introduction 1

Soil, Water, and Plant Resources in Oklahoma — Patterns and Trends -- Ralph S. Matlock 2

Livestock Production - Patterns and Trends -- James C. Hillier ...... (No paper received)

Management and Utilization of Forages in Okoahoma -- Wilfred E. McMurphy 28

Pearl Millet Breeding -- Glenn W. Burton 32

Breeding Forage Sorghum Hybrids -- L. G. Dalton 34

Some Aspects of Summer Annual Grass Production -- Henry A. Fribourg.. 38

Pros and Cons of the Utilization of Summer Annuals in a Beef Cattle Program -- A. E. Spooner 45

Role of Summer Annuals in a Dairy Forage Program -- H. D. Ellzey 47

Prussic Acid (HCN) Potential of Sorghum and its Effects on the Animal -- J. C. Burns 51

Nitrate Nitrogen Accumulation in Summer Forages -- Billy B. Tucker... 67

Summer Annual Legumes -- Ian Forbes, Jr. 81

Committee Reports:

Pre-Conference Executive Committee Meeting 83

SPFCIC General Business Meeting 83

Report of Forage Evaluation Committee 85

Report of Resolutions Committee 86

Post-Conference Executive Committee Meeting 87

Page

SOUTHERN FORAGE BREEDERS' WORK GROUP, July 6, 1971 89

The Role of the Plant Breeder on the Maintanance of Germplasm -- R. C. Leffel 89

The National Program of Collecting, Cataloguing, Storing, and Distributing Germplasm -- W. R. Langford 94

Methods of Preserving and Utilizing Genetic Diversity in Germplasm -- Glenn W. Burton 95

The National Seed Storage Program at Fort Collins -- Howard L. Hyland. 95

Some International Programs and Problems of Plant Exploration and Introduction -- Jack R. Harlan 97

SOUTHERN FORAGE PHYSIOLOGY AND ECOLOGY WORK GROUP, July 6, 1971........ 99

Do We Need Legumes in Pastures? -- A. E. Kretschmer, Jr. 99

White Clover in Perennial Summer Grass Sods -- C. C. King 102

Perennial Legumes for Pastures in the Lower South -- C. Y. Ward and V. H. Watson 104

Legumes in Perennial Cool-Season Grass Sods -- Upper Southeast -- T. H. Taylor and W. C. Templeton, Jr. 106

Winter Annual Clovers in Perennial Summer Grass Sods -- A. E. Spooner 109

Summer Legumes in Perennial Grass Sods -- Ian Forbes, Jr. 110

SOUTHERN FORAGE EXTENSION WORK GROUP, July 6, 1971 111

The Oklahoma Extension Forage Program -- Loren Rommann 111

Forage in Eastern Oklahoma -- Jack Ryan 112

Winter Small Grain for Pasture in South Central Oklahoma -- Robert Treadwell 113

Tall Wheatgrass, Triticale, Weeping Lovegrass - Their Forage Potential for Northcentral Oklahoma -- Dale M. Fain 114

Irrigated Brome-Alfalfa Pasture in Northwest Oklahoma -- Jim V. Howell 115

Summary of Extension Forage Crops Program in Mississippi -- Hiram D. Palmertree 117

Page

East Texas Forage Program -- J. N. Pratt 119

Programs for Improved Forage Systems -- Joe D. Burns 134

Forage is Big Business in America -- Warren C. Thompson 135

Publications -- Georgia Extension Service -- W. H. Sell 138

Trends in Forage Publications for North Carolina --
E. Lamar Kimbrough 139

Publications - Kentucky -- Warren Thompson
(No paper received)

Trends in Forage Publications -- H. W. Wellhausen 140

Forage Programs that Work -- David Jones
(No paper received)

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Registration List--1971 142

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Reported by R. C. Leffel, Permanent Secretary,
USDA, Beltsville, Md.

SOUTHERN PASTURE AND FORAGE CROP IMPROVEMENT CONFERENCE
July 7, 1971

David H. Timothy, Chairman

INTRODUCTION

Opening Session:

The Twenty-eighth meeting of the Southern Pasture and Forage Crop Improvement Conference was opened by Conference Chairman, D. H. Timothy. Chairman Timothy introduced all present, by States represented. C. M. Taliaferro announced arrangements for travel to the field tour to the Fort Reno Field Station for the morning of July 8, and for transportation to the Oklahoma City Airport after the field tour.

Soil, Water, and Plant Resources in Oklahoma - Patterns and Trends

Ralph S. Matlock
Oklahoma State University

I am pleased to have this opportunity to discuss the general patterns and trends of our water, soil and plant resources since they form the base for a prosperous animal agriculture.

WATER

Sources of water for livestock and man include farm ponds, large reservoirs, soil water, floodwater detention reservoirs and major streams, such as, the Arkansas, Cimarron, Canadian, and Red Rivers.

We have over 100,000 farm ponds in Oklahoma and estimating an average of five acre feet of water per pond provides 500,000 acre feet or 15 billion gallons of water. The 13 large reservoirs filled to the top of flood pool provides 10,000,000 acre feet or 300 billion gallons but most of this is not available for agricultural use. We have 44 million acres of land in Oklahoma. Our annual precipitation varies from 50 inches in SE to less than 20 in NW High Plains. If we had 6 inches of water in the profile we would have 22,000,000 acre feet or 660 billion gallons of water. This is available to plants growing in the soil. In 1969 we irrigated 619,275 acres (Table 1) or about 4% of our crop and improved pasture land on 4,520 farms in 77 counties. Most irrigation occurs in 10 counties located in High Plains, Western, and SW Oklahoma. The principle crops irrigated include grain sorghum, wheat, improved pasture, cotton, peanuts, and corn. The costs for water and labor run about $1.25 per acre inch applied depending on numerous factors.

SOILS

Oklahoma soils vary widely in the nature of the parent material, topography, age and properties, such as, particle size, organic matter, pH, and cation status. We have divided the State into nine soil resource areas and related this to acres of pasture and range by land capability classes. It should be pointed out that there are many different soil series within each resource area. These units would need to be planned and studied individually.

A summary of the nine soil resource areas showing total acres and acres in Pasture and Range by Land Capability Classes I-IV, V-VII is shown in Table 2.

Ouachita Highlands (See Map and Table 3) in southeastern Oklahoma is characterized by a series of parallel ridges running generally east and west. The rugged surface relief and sizeable acreages of stony, shallow soils developed from weathering sandstone and shale. This resource area contains nearly 500,000 acres in pasture and rangeland in Classes I through IV and another 500,000 acres in classes V through VI.

The Ozark Highlands (See Map and Table 4) located in the NE Oklahoma also has variable surface relief, contains 1.6 million acres of cherty to very cherty soils. Pasture and range make up only about 14 percent of this area.

Forested Coastal Plains (See Map and Table 5) contains 1,394,000 acres in SE Oklahoma. Most of the soils in this area are sandy and developed from beds of unconsolidated sands, clays, and sandy clays. Pasture and range make up about 18 percent (246,199 acres) of Classes I through IV and 12% classes V through VI.

The Cherokee Prairies (See Map) make up 6,454,000 acres in central and NE Oklahoma. The surface relief is gentle to somewhat rolling. The annual precipitation runs from 35 to 45 inches. The soils have developed from the weathering of shales, sandstone and some limestone under the cover of tall grass prairie. Low ridges of outcropping sandstone traverse the area and these soils are generally sandy, shallow and non-arable. The bluestem hills are included in the NW part of the resource area. The pasture and range (Table 6) constitute 3,776,279 acres of which 2,568,102 acres is classes I through IV. This area offers possibility of expanded forage production that staggers one's imagination.

The Cross Timbers (See Map) is another large resource area (6,214,000 acres). The surface relief ranges from gently rolling to hilly. Predominant soils were sandstone derived and under natural conditions support mainly post oak and blackjack oak savana vegetation.

The area (Table 7) has in excess of 1.5 million acres of Class I, II, III land in pasture, range and timber. This cross timber is rapdily going to improved pasture and we expect to see this trend continue.

The Grand Prairies (See Map and Table 8) in southern Oklahoma contain 1,772,000 acres. The surface relief ranges from gently wavy to rolling and hilly. The soils were developed from limestone on shale under the cover of tall grasses. These soils are predominantely dark colored and heavy or clayey. About 70% of this area is in pasture and range. Forage production can be improved considerably.

The Reddish Prairies resource area (See Map) occupies a wide belt in central Oklahoma and contains 8,586,000 acres of wavy to gently rolling surface relief. The soils developed under a grass cover over weakly calcareous red shales and sandstones. This area (Table 9) has the highest concentration of cultivated cropland but about one-half of the area is devoted to pasture and range land. About 2.25 million acres belong to land capability classes I through IV and 2.25 million to classes V through VII. This is a transition area between the pedalfers soils of the east and pedocal soils of the west. Some forage production improvement is possible but the potential for pasture expansion is not as favorable as for the Cross Timbers and Cherokee Prairies resource areas.

The Rolling Red Plains (See Map and Table 10) make up vast resource area of 9,442,000 acres. Like the rest of the State it tilts toward the southeast with elevation being 1,000 feet on the east to 3,000 on the west. Surface is rolling with deep-cut valleys and narrow strips of alluvium soils. Most of the 20 to 30 inches of precipitation occurs between April and September but the distribution is irregular and droughts are common. One-third of the area is in pasture and range with 1.5 million acres in Classes I through IV.

The High Plains (See Map and Table 11) contain 3,844,000 acres of land sloping from northwest to southeast between 3,000 to 4,500 feet above sea level. Only 15 to 20 inches of rainfall occur. These soils have developed from outwash material imported from higher elevations of the west.

PLANTS

Plant Resources - An idea of the general vegetation can be obtained from the game and vegetation map by Duck and Fletcher. We have commercial timber in southeast, post oaks, black-jack oak and tall grass mixtures scattered through the central area, mesquite-grass in southwest, shinnery oak-grassland in west central and sand-sage grassland mixture in northwest and pinon-juniper-mesa vegetation in the Panhandle.

The plant resource groups (Table 12) summarized show 26 million acres (59.2%) grazed or partly grazed grassland including native range, grazed commercial and non-commercial forest and improved pasture. Not too many years ago we had 20 million acres of cultivated cropland. We planted about 13 million acres in 1969.

In the grazed and ungrazed timber woodland or forested area we have about 2 million acres in land capabilities in classes I through IV and about 5.5 million acres in classes V through VII in four of the resource areas (Table 13). Ouachita Highlands resource area contains about 3.4 million acres of grazed and ungrazed timberland. About 85% (3 million acres) belong to land capability classes V, VI, and VII. Some of the low value commercial timber areas may be more productive in forage than timber. Forested Coastal Plains resource area has over 800,000 areas in grazed and ungrazed timberland with about 400,000 each in classes I through IV and V through VII. The long growing season, rainfall and soils favor increased forage production. Cross Timbers resource area contains 2.4 million acres in grazed and ungrazed post oak and black-jack oak. About one-third of this is in land capability classes I through IV and two-thirds in classes V through VII. Criterion for helping ranchers to decide which areas to clear for pasture and range production need to be clearly established.

In summary, we have about 9 million acres covered with tree and brush of low commercial value. This consists mainly of 4.5 million acres of post oak-blackjack oak, 1.0 million acres of mesquite, 0.6 million acres of shinnery oak and about 3 million in sumac, willow, salt cedar, red cedar, sand-sage, persimmon, sassafras, elm and buckbrush. Possibly 75% or about 7 million acres in brush and non-commercial timber could be developed into more productive pasture and range use without reducing environmental quality and at

the same time providing more feed for wildlife if the proper guides are followed.

The trends (Table 14) in our land use are illustrated by comparing the acreages in 1958 and 1967 compared with estimates in year 2000.

We expect the cropland to decrease another million acres by year 2000 and to take on some stabilization effect due to food, feed, and fiber needs. We are suited for animal production since forage, range and pastures provide economical sources of energy and provides landowners opportunity to practice the art and science of good land use. Thus, we expect pasture and range to increase another 3.7 million acres by year 2000. It is expected that the less productive or non-commercial forested area will be utilized for improved pasture and range.

During the past 20 years (1949 to 1969) the acre yield for most crops have doubled. We should again double the acre yields by year 2000.

The major shift in cropland has been a reduction in wheat, cotton, and peanut acreages and an increase in certain feed grain and pasture crops. I would like to review the 1969 crop production in Oklahoma.

CASH AND FEED GRAIN CROPS (Table 15)

Some wheat is grown in each county but 68% (2,930,900 acres) of the acreage and nearly 75% of the production is grown in 15 counties in the Reddish Prairies and Rolling Red Plains and two counties in the High Plains.

In the 14 counties in the Reddish Prairies and Rolling Red Plains we harvested 75% of the barley acreage and nearly 80% of the barley grain. Likewise nearly 50% of the oat acreage and production was located in 12 counties.

Grain sorghum is primarily produced in the western part of the State in the High Plains, Rolling Red Plains, and the Reddish Prairie resource areas. Nearly 70% of the acreage and 75% of the production is located in 14 counties. About 60% of 92,000 acres of corn harvested in 1969 was located in irrigated sections of Texas & Cimmarron counties in high plains. About 60% was harvested for grain and 40% for silage. The acreage of corn continues to increase in the high plains area.

FORAGE CROPS (Table 16)

Alfalfa and prairie hay make up nearly 60% of the hay acreage and 67% of the hay production. These 14 counties make up about 45% of acreage and 50% of the alfalfa production. About one-third of the acreage and production of prairie hay is harvested in the seven counties in the northern part of the Cherokee prairies.

OTHER CASH CROPS (TABLE 17)

Cotton acreage has moved from SE Oklahoma to SW Oklahoma and 11 counties

make-up 78% of the acreage and 81% of the production.

Over 50% of harvested peanut acreage is concentrated in three counties (Caddo, Hughes, and Bryan) though they are grown in 45 of the 77 counties.

Harlan (Production characteristics of Oklahoma Forages - Native range B-547, 1960) reported that the limiting factors of native range production are rainfall, soil fertility, soil texture, and management of the grass. We are optimistic about producing forage and feed grain for livestock.

The assets for forage and feed grain production in support of animal production are summarized below:

Forage	Acres	000,000 lbs.
Native Range	15,000,000	30,000
Improved Pasture	2,500,000	15,000
Small Grain Graze-out	500,000	5,000
Small Grain Grazing	4,000,000	4,000
Native Hay	400,000	1,000
Alfalfa	600,000	3,000
Other Hay	700,000	2,000
Total	23,700,000	60,000

Feed Grain	Acres	000,000 lbs.
Wheat	1,400,000	2,400
Sorghum	640,000	1,500
Corn	60,000	225
Barley	425,000	725
Total	2,525,000	4,850

It is evident that 60 billion pounds of forage produced on 24 million acres should carry a lot of animal units. Five billion pounds of high energy grain produced on 2.5 million acres should fatten 1.6 million cattle.

Oklahoma's agriculture potential has not been reached. The potential for further increasing food and fiber production in the State is great. Through continued research and sound planning and utilizing the resources of water, soils, and adapted crops we hope to realize these potentials. It is also our desire through proper land use planning to effect a prosperous productive agriculture and at the same time to have multiple land use for crops, livestock, wildlife, and recreation while maintaining soil productivity by reducing erosion.

TABLE 1

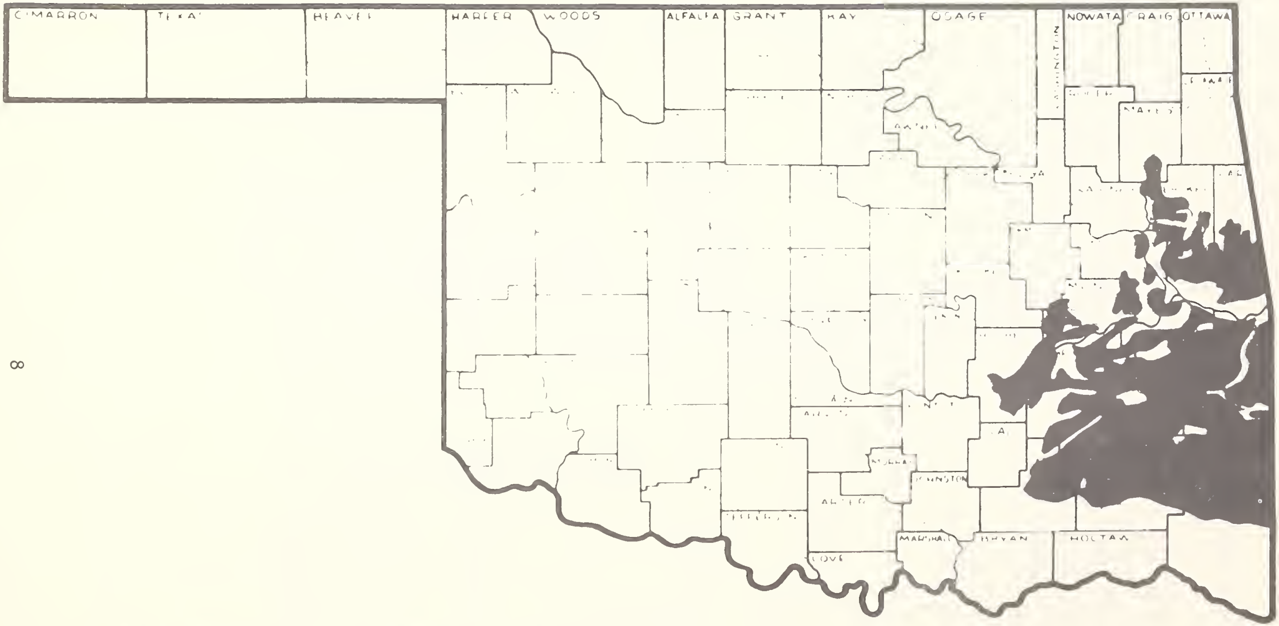
CROPS IRRIGATED IN OKLAHOMA 1969

	ACRES
Small Grains	134,452
Gr. Sorghum	223,518
Corn (Grain)	31,725
Alfalfa	62,315
Sorghum (Forage)	12,281
Corn (Forage)	32,477
Pasture	62,227
Cotton	53,190
Peanuts	47,556
Horticulture	6,371
Other	3,698

TABLE 2

OKLAHOMA LAND RESOURCE AREAS

RESOURCE AREA	ACREAGES		
	TOTAL (000)	PASTURE AND RANGE LAND CAPABILITY CLASS I-IV	V-VII
Ouachita Highlands	4,614	479,722	440,139
Ozark Highlands	1,600	183,628	43,924
F. Coastal Plains	1,394	246,199	166,312
Cherokee Prairies	6,454	2,568,102	1,208,177
Cross Timbers	6,214	740,023	968,599
Grand Prairies	1,772	793,044	443,074
Reddish Prairies	8,586	2,280,036	2,251,139
Rolling Red Plains	9,422	1,568,562	622,081
High Plains	3,844	597,892	1,116,870
Total	43,900	9,457,208	7,278,315

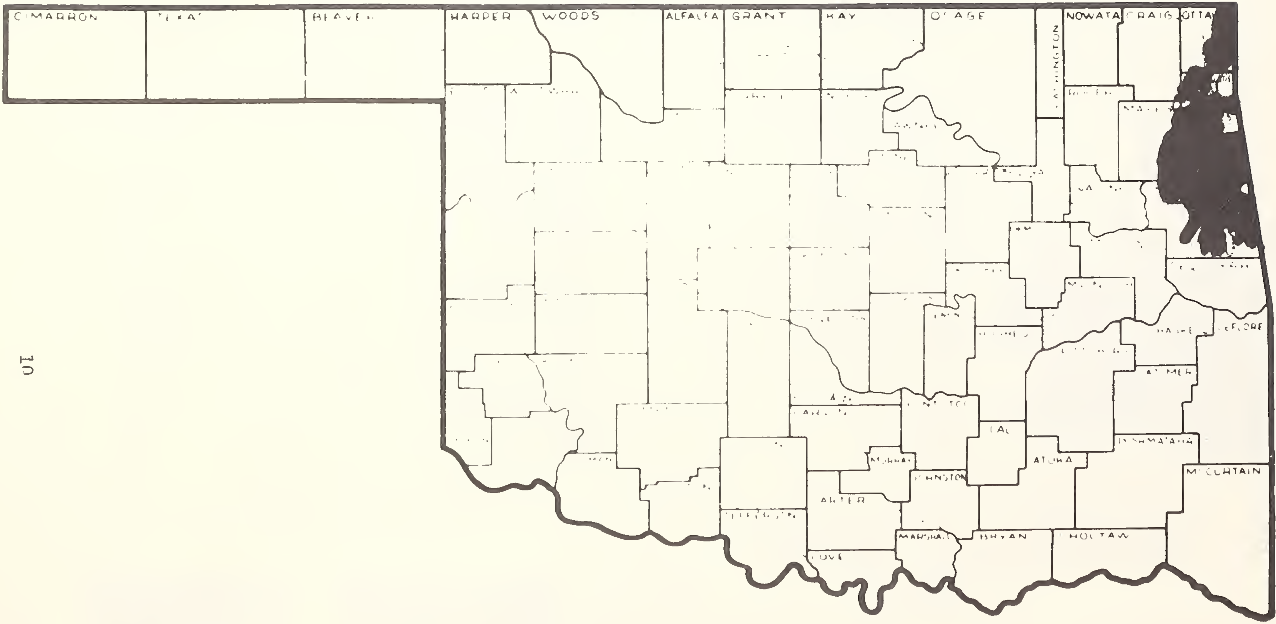


OUACHITA HIGHLANDS

OUACHITA HIGHLANDS
4,614,000 Acres

Class	Pasture & Range	Timber Grazed and Ungrazed
I	12,000	2,715
II	173,901	178,250
III	155,454	166,044
IV	138,367	147,091
V	17,285	184,054
VI	193,455	581,727
VII	229,399	2,224,767
TOTAL	919,861	3,484,648

Grand Total : 4,404,509



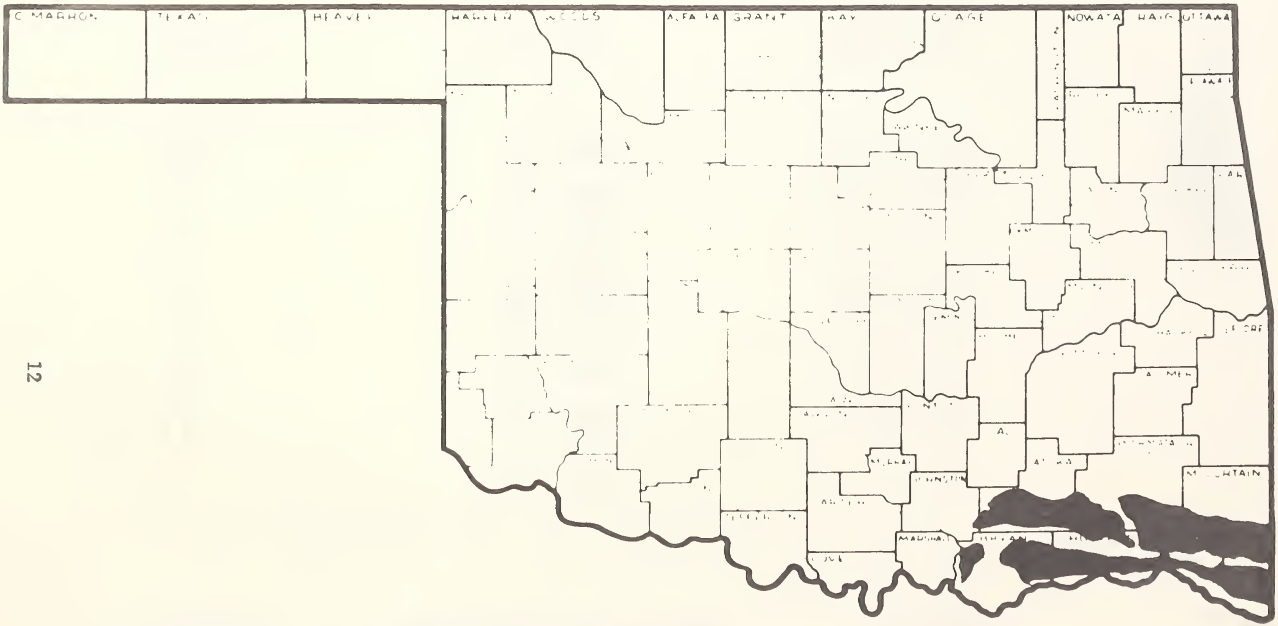
OZARK HIGHLANDS

OZARK HIGHLANDS COMPLETE

1,600,000 Acres

Class	Pasture & Range	Timber Grazed and Ungrazed
I	70,561	2,564
II	49,000	40,934
III	37,852	47,385
IV	89,720	161,563
V	6,424	20,137
VI	23,000	217,163
VII	14,500	306,587
TOTAL	227,552	796,333

Grand Total : 1,023,885



FORESTED COASTAL PLAIN

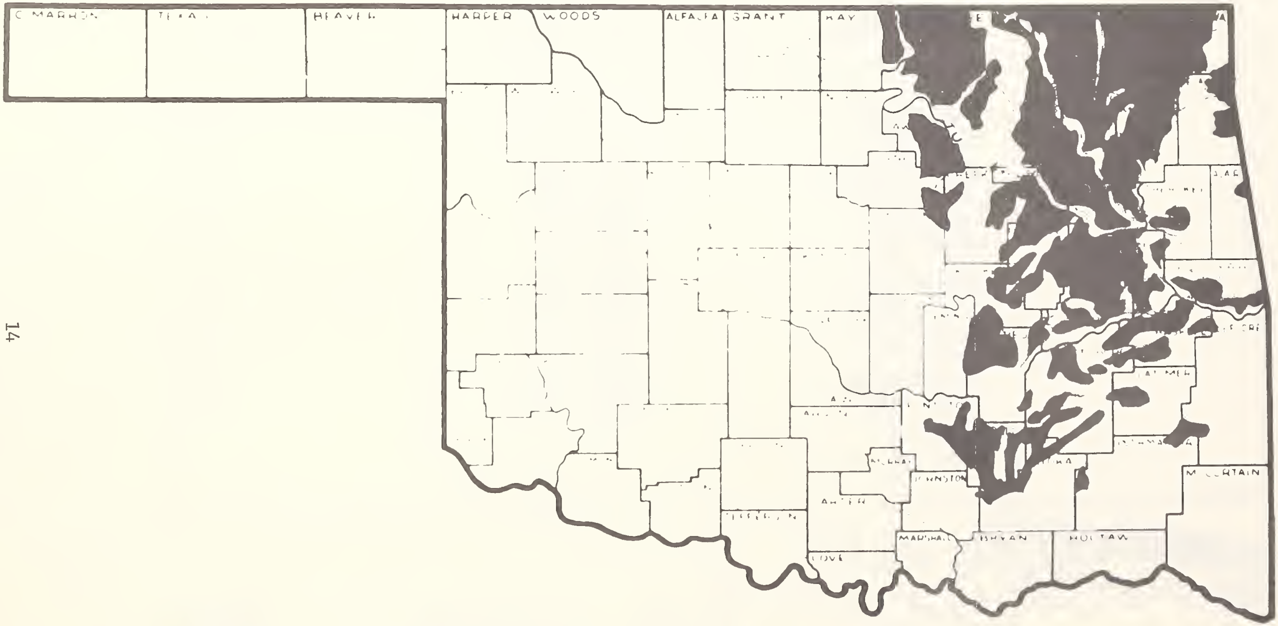
TABLE 5

FORESTED COASTAL PLAINS (FC)

1,374,000 Acres

Class	Pasture & Range	Timber Grazed and Ungrazed
I		4,000
II	117,600	188,855
III	79,000	171,150
IV	49,598	103,549
V	8,100	5,000
VI	69,340	324,745
VII	88,873	48,651
TOTAL	412,511	841,951

Grand Total : 1,254,462



EASTERN (CHEROKEE) PRAIRIES

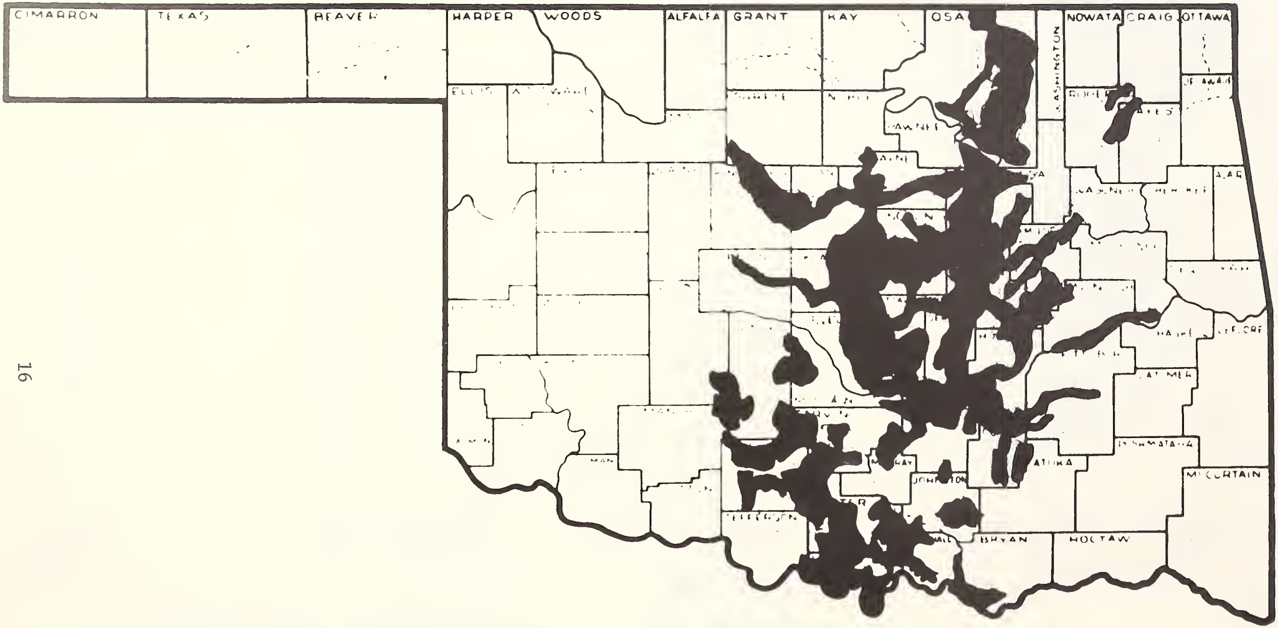
TABLE 6

EASTERN OKLAHOMA (CHEROKEE) PRAIRIES

6,454,000 Acres

Capability Class	Acres Pasture and Range	Conservation Use	Open Land Formerly Cropped
I	102,641	13,557	1,629
II	1,194,560	137,002	20,718
III	880,470	64,092	12,279
IV	390,431	18,385	12,784
V	56,300		
VI	510,598	14,652	2,894
VII	641,279		
TOTAL	3,776,279	247,688	54,304

Grand Total : 4,078,271



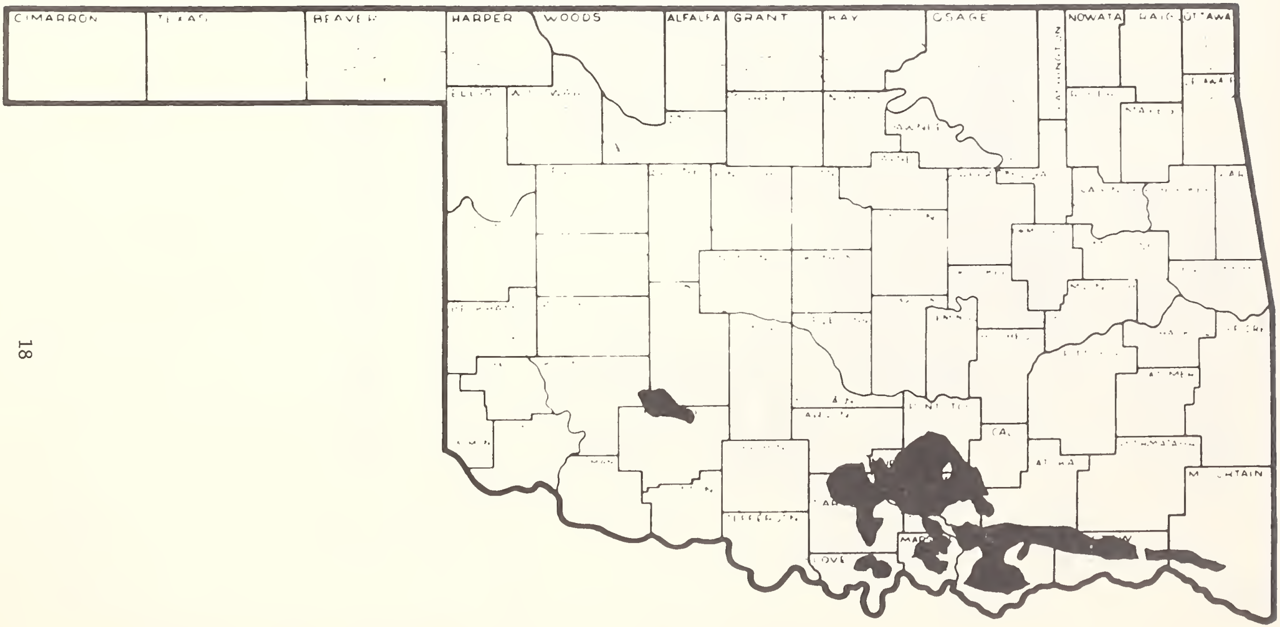
CROSS TIMBERS

TABLE 7

CROSS TIMBERS
6,214,000 Acres

Class	Pasture & Range	Timber (Black Jacks)
I	19,121	21,687
II	178,813	141,485
III	282,678	247,208
IV	259,411	364,893
V	51,198	147,103
VI	635,744	1,030,616
VII	299,657	491,899
TOTAL	1,726,622	2,444,891

Grand Total : 4,171,513

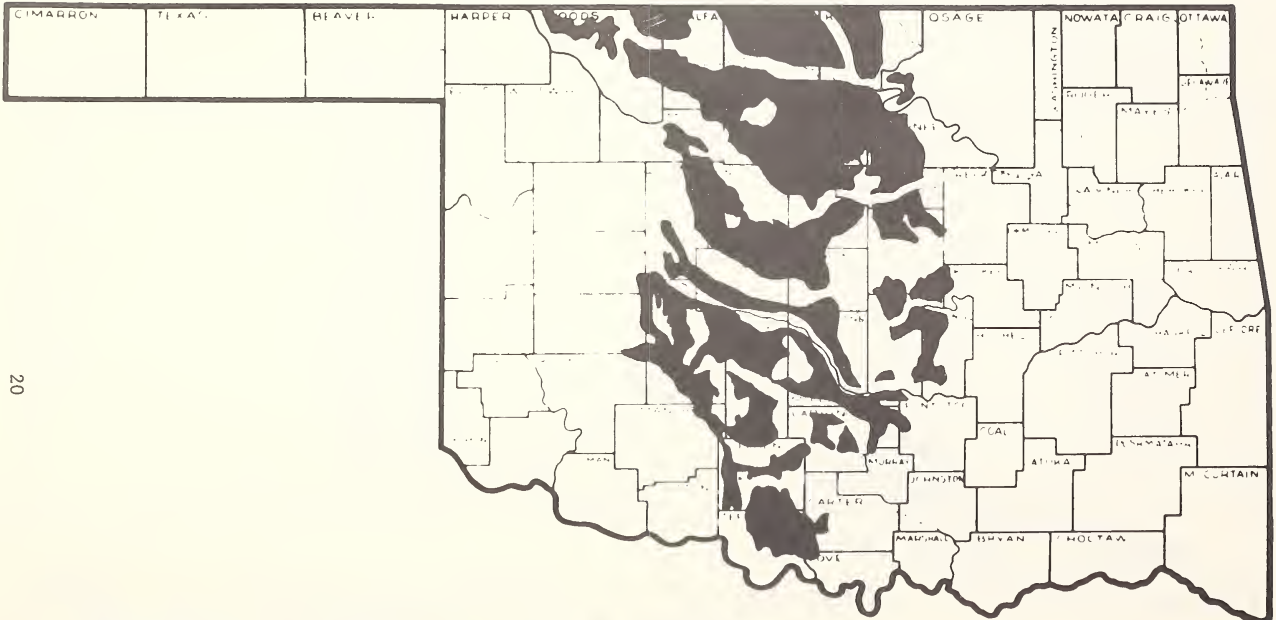


GRAND PRAIRIES

GRAND PRAIRIE
1,772,000 Acres

Class	Pasture & Range	Temporarily Idle	Conservation Use
I	46,696		1,000
II	300,226	800	30,300
III	234,508	1,500	10,400
IV	211,614		1,400
V	9,577		
VI	228,771		
VII	204,726		
TOTAL	1,236,118	2,300	43,100

Grand Total : 1,281,518



CENTRAL REDDISH PRAIRIES

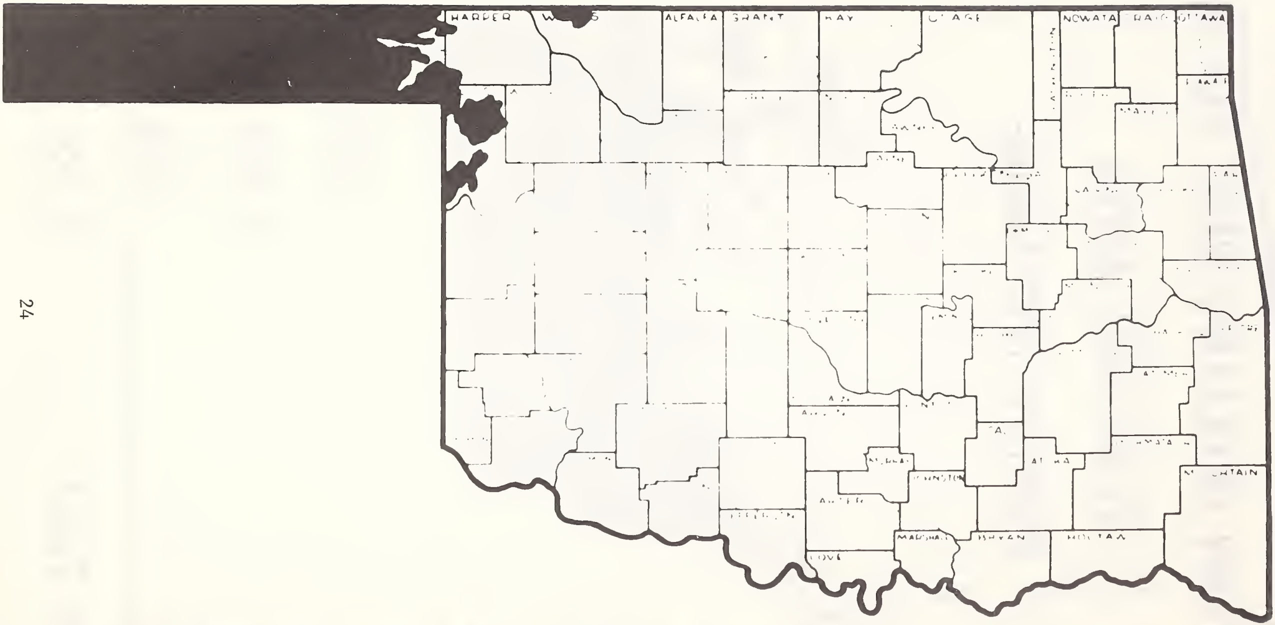
TABLE 9

REDDISH PRAIRIE

8,586,000 Acres

Pasture and Range

Class	Total
I	77,766
II	461,420
III	796,688
IV	944,162
V	151,331
VI	1,648,784
VII	451,024
Grand Total	4,531,175



HIGH PLAINS and BREAKS

TABLE 11

HIGH PLAINS

3,884,000 Acres

Pasture and Range

Class	Total
I	
II	
III	221,707
IV	376,185
V 1	53,123
VI	904,909
VII	158,835
Grand Total	1,714,759

TABLE 12

PLANT RESOURCES IN OKLAHOMA

ITEM	ACREAGES (000)
NATIVE GRASSLAND	14,713
GRAZED NON-COMMERCIAL FOREST	3,703
GRAZED COMMERCIAL FOREST	3,364
PASTURE LAND	4,241
LAND GRAZED 26,021	
NON GRAZED FOREST	1,594
OTHER	3,292
CROPLAND	12,993
TOTAL	43,900

TABLE 13

GRAZED AND UNGRAZED TIMBERLAND

RESOURCE AREAS	I-IV	V-VII	TOTAL
	LAND CAPABILITIES CLASSES		
QUACHITA HIGHLANDS	494,100	2,900,548	3,394,648
OZARK HIGHLANDS	252,446	543,887	796,333
F. COASTAL PLAINS	467,554	378,397	845,951
CROSS TIMBERS	775,273	1,669,618	2,444,891
TOTAL	1,989,373	5,492,450	7,481,823

TABLE 14

LAND USE TRENDS IN OKLAHOMA

	1958	1967	2000	Change (000,000)
CROPLAND	14,730,200	12,992,600	12,000,000	-1.0
PASTURE	1,472,600	4,241,000	7,241,000	+3.0
RANGE	13,817,500	14,712,700	14,012,700	+0.7
FOREST	9,390,900	8,580,900	6,000,000	-2.6
OTHER	1,710,900	438,000	746,300	+0.3
TOTAL	41,122,100	40,965,200	40,000,000	-0.4

TABLE 15

1 ACRES AND PRODUCTION
OKLAHOMA CROPLAND, 1969

CROP	ACRES HARVESTED (000)	PRODUCTION lbs/A.	PRODUCTION TOTAL lbs. (000)
WHEAT	4,155	1710	7,096,000
BARLEY	422	1680	708,960
OATS	158	1312	207,296
RYE	49	1200	58,800
CORN	58	3900	226,200
SORGHUM	638	2632	1,426,544
TOTAL	5,480		9,723,800

TABLE 16
11 ACRES AND PRODUCTION
OKLAHOMA CROPLAND, 1969

CROP	ACRES HARVESTED (000)	PRODUCTION lbs/A.	PRODUCTION TOTAL lbs. (000)
CORN (FORAGE)	34	4000	136,000
SORGHUM (FORAGE)	300	3000	900,000
ALFALFA HAY	581	5400	3,138,000
PRAIRIE HAY	371	2500	928,000
OTHER HAY	702	2800	1,970,000
TOTAL	1,988		7,072,000

TABLE 17
111 ACRES AND PRODUCTION
OKLAHOMA CROPLAND, 1969

CROP	ACRES HARVESTED (000)	PRODUCTION lbs/A.	PRODUCTION TOTAL lbs. (000)
COTTON	465	288	139,500
PEANUTS	120	1700	204,000
SOYBEANS	204	1020	208,080
MUNGBEAN	34	400	13,600
BROOMCORN	31	370	114
TOTAL	854		565,294

Management and Utilization of Forages in Oklahoma

Wilfred E. McMurphy
Oklahoma State University

The rapid increase in beef cattle numbers in Oklahoma speaks of the success of our forage-beef industry. Oklahoma will continue to be a major cow-calf State because we can produce an abundance of the lower quality roughage. I refer to forage as being high quality if steers can gain approximately 1 3/4 pounds or greater per day. Our major grazed forages are native grass, bermudagrass, weeping lovegrass, small grains, and tall fescue. These grasses produce abundantly on a large acreage which is unsuited for cropping or is too droughty for a high-quality, cool-season perennial grass. We can compete with other States in wintering this beef cow using dry grass with protein supplements in central and western Oklahoma and with cool-season grasses in eastern Oklahoma.

Our rainfall varies from less than 16 inches in the panhandle to 50 inches in the southeast. At any given location, the year to year precipitation varies just as much. Unfortunately, we seldom have a single dry year; dry years come together. Oklahoma experienced a series of very dry years in the early teens, the early 30's, the early 50's, and it is beginning to appear that predictions of a 20-year drought cycle may be right because the early 70's are getting a dry start.

Table 1, showing average monthly precipitation, may help explain the problem in forage production. East central Oklahoma lies just west of Ft. Smith, Arkansas, receives 43 inches on the average, and gets a minimum of 2 inches every month -- on the average. Although a 2-month dry spell with practically no precipitation can be expected every year, a tremendous amount of forage can be produced even in a serious drought year. Both cool and warm season grasses have their place in a pasture program in eastern Oklahoma. Western Oklahoma is a different environment. Average monthly precipitation is about 1 inch from November through March (5 months). A 4-month dry spell is not uncommon. Most of the rain falls from April through July, and the temperature quickly gets too hot for cool season perennial grasses.

Wheat is the dominant crop because enough moisture can be accumulated through late summer that a single good rain enables farmers to plant and get the crop established. With adequate fall moisture, a stocker cattle operation is used to consume this forage. For years, farmers traditionally grazed their wheat pasture from late October until early March, then removed the cattle when the wheat began to elevate its growing point and saved the entire crop for a grain harvest. However, economics are squeezing out the short duration grazing and more wheat is being completely grazed out. In a normal year, farmers may pasture all of their wheat until March, they concentrate the cattle on 1/3 of their total acreage for graze out and harvest grain from the remaining 2/3 of their acreage. In a dry year such as this past spring, many of these operators had to use more of the spring production for grazing, but this gives them greater flexibility and grain yields would be low enough that

grazing was a more profitable alternative. Production ranges from 300-500 lbs beef/acre. The major limiting factor is the low forage production during the cold winter months.

Out in the Oklahoma Panhandle, much forage is harvested and placed in large trench silos for the feedlot industry. Increasing interest in irrigated bromegrass-alfalfa pasture is developing. These are center pivot type irrigation systems with the well in the center of the 160 acres. Such circular systems will irrigate about 132 acres of the 160. Management is a critical problem because these operators will start with no grass in March, and by April it is warm enough for a rapid growth rate, and large numbers of steers are needed. These systems must be associated with a feedlot operation to have the flexibility in cattle numbers, and rotation grazing will be necessary to obtain proper utilization of the forage produced. These are large operators, and a single pasture will be 160 acres or larger. These irrigation systems are expensive and beef production must exceed 500 pounds of beef/acre just to meet the expenses.

As we come east of the Panhandle to western Oklahoma, we find an abundance of native range. Some of this is in excellent condition and producing about the most that can be expected on these soils in this dry region. It takes 15-20 acres to supply forage for one cow year-round with protein supplement given during the winter. However, some owners get careless or optimistic and their ranges may resemble a golf course putting green by August, especially in a dry year such as last year. Pasture men won't get excited if their pasture is grazed that close, but the removal of too much leaf area reduces root food reserves, weakens the desirable species, and reduces next year's range production. In fact, it may take 2-5 years for range to recover to normal production from 1 year's close grazing. One of our best range improvement practices which helps restrict this overgrazing is an introduced grass pasture. Introduced grasses have regrowth potential. A rain in August or September will still produce a crop. Native range does not have this regrowth potential, and a late summer rain serves to make the range look greener, but production is very limited.

There are about 0.6 million acres of shinnery oak in western Oklahoma producing about 500 pounds of grass/acre annually. Spraying with 2,4,5-T will clean up much of the oak problem and triple grass production. But, even with excellent control, some oak often remains. Shinnery is one of the first range plants to produce green spring growth, and 3 years ago several ranchers lost 30-60 cows each from shinnery poisoning. These soils which support shinnery are excellent for weeping lovegrass and many ranchers are now clearing this brush, deep plowing, and planting weeping lovegrass. Weeping lovegrass seedlings are vigorous growers and very drought tolerant. A lot of weeping lovegrass was planted in the late 30's and early 40's in Oklahoma, and many management mistakes were made. Many ranchers used to have the opinion that cows would eat one another before they would eat weeping lovegrass. That attitude has changed, but the statement holds some merit if only mature, unfertilized weeping lovegrass is considered. In early spring, a rancher must remove the old dead growth of lovegrass either by mowing or burning. Then nitrogen fertilizer is a must or crude protein will be below maintenance requirements

all year except for 2 weeks in the spring. Several years ago when nitrogen cost 15¢/pound and steers sold for 22¢, there was little future in it, but steers now sell for 35¢ or more and nitrogen is 7¢/pound. The economics have changed. Then the grazing management must be some form of rotation to utilize the grass before it reaches its fast maturity, and then permit regrowth to replenish root food reserves before regrazing. If a rancher can convert 15% of his range area into weeping lovegrass, he can double the number of cows on the ranch. Weeping lovegrass has a place on the sandy upland soils of western and central Oklahoma.

Bermudagrass has a place in western Oklahoma in small bottomland areas to take the grazing pressure off the native range. These ranchers figure that conversion of 10% of their total range acreage into bermudagrass will enable them to carry twice as many cows. Thus, bermudagrass serves in the bottomland areas while weeping lovegrass serves the sandy uplands.

Sugar drip sorgo is an annual forage uniquely adapted to Oklahoma conditions. Planted in mid-July, sugar drip will be in the late boot to early heading stage by frost with 5-6 tons of dry matter/acre. By December 1, it has frosted and cured in the field with a crude protein content ranging from 5-7%, marginal for a dry cow, and in vitro dry matter digestibility of 35%. It is a low quality forage but well suited to dry beef cows, which have gained 1 pound/day during December, 1/2 pound/day in January and broke even in February. After calving, a better ration is needed. For central Oklahoma, bermudagrass sod-seeded to small grains will produce excellent green pasture beginning in March. Sugar drip is best for central and western Oklahoma because the high winter rainfall of eastern Oklahoma causes too much loss by rotting of that forage laying on the ground. For dry cows, no additional supplement has been needed until calving and 1/3 acre will supply the winter forage for 1 cow for 3 months.

In central and eastern Oklahoma is a brush problem of several million acres classified as non-commercial forest. Twenty years ago the answer seemed to lie with herbicides, and while improvements have been made, we still have a brush problem. Even with the best control, a source of propagation remains. Sometimes even if good control of the blackjack and post oak is obtained, the wrong species is released. When no native grass remains for propagation only pokeweed, marestail, and low order grasses are released. Broomsedge has often been released from brush competition in eastern Oklahoma. A serious problem in eastern Oklahoma is resistant woody species such as winged elm, hickory, hackberry, and others which survive the herbicide, then rapidly increase presenting the rancher with an even more difficult brush problem. In central Oklahoma we are seeing more bulldozing followed by annual cropping such as small grain pasture to kill the sprouts by tillage, and then bermudagrass.

Another problem area of central and eastern Oklahoma are the areas once cultivated (part of the 7 million acres of former cropland) but returned to native grass in the past 30 years. Topsoil and nutrients have disappeared, and now brush is encroaching on the old terrace tops and erosion patterns where pollution of runoff water by silt still occurs. These gullied

grasslands are a monument to the homestead law of 1862 which required at least 40 acres of each 160 to be plowed. It was a gross mistake. These lands will support bermudagrass and when fertilized an agriculture pollution problem can be corrected. The Old World bluestems, Bothriochloa spp., will have a place on these old fields. On a tight claypan soil, 3 1/2 tons of forage/acre were produced while nearby after 15 years abandonment from cultivation the production was less than 1 ton of dry matter (composed of threeawn, annual bromes, and weeds).

In eastern Oklahoma, many of these old fields which might be called broomsedge pastures were actually sprigged to bermudagrass years ago. Presently, they are closely grazed, weedy and low in production. All they need is mowing and fertilization to develop a good common bermudagrass pasture with 2 acres or less required to support a cow.

Bermudagrass has made a tremendous impact on the cow-calf industry. During the past 10 years the 53% increase in beef cow numbers occurred with a 1 million acre increase in bermudagrass in Oklahoma. Over 700 pounds of beef/acre has been produced at Muskogee. Enough forage was produced to supply 1 cow for 1 year on one acre using 300 pounds of nitrogen/acre. Midland bermudagrass is the best variety across northern Oklahoma because it is more winter hardy than Coastal. Every time some farmer sprigs 4 acres to common bermudagrass, he has thrown away 1 acre of land because 3 acres of Midland will produce as much as 4 acres of common.

In eastern and central Oklahoma small grains can be interseeded into bermudagrass in October using a standard stubble mulch drill with narrow chisel points. Too often farmers try to plant too deep so we recommend that they pull a large drill with a small tractor. Thus, they merely scratch the soil surface, place seed and starter fertilizer on the soil and the press wheel compacts it. Very little grazing is available during the winter, but by March an abundance of high quality forage is available. In southern Oklahoma the warmer winters sometimes give winter grazing. This operation will give a minimum of two extra months grazing with high quality forage (2 pounds/day gain on steers) with 100-300 pounds of beef/acre of extra production depending upon fertility level. This year, 1971, was a very dry spring at Muskogee and on some of the soils it was still worthwhile.

Some work in east central Oklahoma, 42-inch precipitation area, on conversion of brush to tall fescue pasture looks promising. A cooperative project with Sarkeys Foundation is underway on some rough, rocky wooded land, the only marketable product being cattle. The area was sprayed with 2,4,5-T in early June for brush control, burned in September to remove the leaf litter, and tall fescue with starter fertilizer was aerially broadcast. A good stand of fescue was obtained. This brush can possibly be converted to pasture and be grazed in less than 1 year for $25/acre.

Smooth bromegrass has a minor role in eastern Oklahoma. It responds to fertility, produces 2 pounds/day gain on steers but gives only 4 months of growing season.

In summary, the outlook for forage and beef production in Oklahoma is very optimistic. It is easy to see how more forage can be produced. The resources and the technology to double and triple beef cow numbers using only the land presently grazed by cattle are available. If our agriculture statistics are right, many counties in eastern Oklahoma have enough pasture that if fertilized and managed, they could double cow numbers without developing further pasture. If fertilizer remains relatively cheap and if calf prices remain 35¢ or better, cow numbers will continue their rapid increase in Oklahoma.

Table 1. Normal monthly precipitation for Oklahoma.

Month	West Central	Central	East Central
Jan	.90	1.44	2.26
Feb	1.00	1.59	2.81
Mar	1.46	2.12	3.23
Apr	2.59	3.43	4.54
May	4.53	5.34	5.97
June	3.39	4.44	5.11
July	2.23	3.01	3.35
Aug	2.22	2.75	3.09
Sept	2.28	3.37	3.76
Oct	2.29	2.94	3.45
Nov	1.02	1.85	2.73
Dec	1.09	1.54	2.48
Total	25.00	33.82	42.78

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Pearl Millet Breeding

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Pearl millet, Pennisetum typhoides, by far the most important millet outside China, Manchuria and Russia, is grown on 45,000,000 acres, primarily for grain for human consumption. It is unusually tolerant of drought and heat and produces grain in regions too hot and dry for other cereals. Although able to grow on poor sandy soils, it has high yield potential and responds well to fertilization and irrigation. Grain yields reported from India range from 350 to 8000 pounds per acre. Pearl millet produces high quality HCN-free forage giving steer ADGs of over 2 pounds and liveweight gains per acre in excess of 500 pounds. It is the best annual summer pasture grass for the sandy soils of the southeastern U.S.A. It has fewer pest problems than other cereals, but birds love the grain and are millets greatest enemy. Ergot, mildew and smut are the most serious diseases.

Pearl millet is a robust annual bunch grass (6'-15' tall) with seeds borne in "cattail-like" spikes (6"-48" long). It may produce up to 30,000 glume-free seeds (4-8 mgm) per plant. Pearl millet is a diploid (2n=14) that reproduces sexually. It is highly cross pollinated due in part to its protogynous flowering habit.

Pearl millet grain contains more protein and oil than wheat, corn, sorghum or rice. Except for lysine deficiency, pearl millet has an excellent amino acid profile. Rats, fed unsupplemented diets of pearl millet, sorghum and maize grains made the highest growth rate on pearl millet.

Pearl millet has received much less research attention than other cereals. The morphological variation in the species equals or exceeds that of such cereals as corn and sorghum. Only a tiny fragment of the world's pearl millet germplasm has been assessed for grain or forage quality. These data indicate that the quality of both the grain and forage of pearl millet can be improved by breeding.

Pearl millet is easy to manipulate in a breeding program. Protogyny permits hybridization without emasculation. Cytoplasmic male sterile stocks currently in wide use permit the commercial production of F_1 hybrids that have yielded nearly twice as much grain as open pollinated varieties in India. Forage hybrids in the U.S. have yielded 50% more than the common cattail variety. We have developed excellent, simply inherited dwarf, early and late characters that can be quickly transferred to otherwise good varieties. We have simple techniques that permit us to produce at least four generations per year.

Pearl millet breeding objectives in the United States include:

1. High forage yield when grazed
2. High forage yield when ensiled
3. Improved forage quality
4. Better seasonal distribution
5. Late season types for fall grazing
6. Disease resistance
7. Insect resistance
8. Bird resistance
9. High seed yields
10. Low temperature germination

Repeated tests at Tifton, Georgia, indicate that at least half the genetic variance for yield in pearl millet is non-additive. It is not surprising, therefore, that hybrids yield up to 50% more forage and 100% more grain than open pollinated varieties. Thus it would appear that pearl millet breeding programs should be directed toward the development of single crosses, 3-way crosses or first-generation synthetics such as Gahi-1 to fully exploit the heterosis that characterizes this species.

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Breeding Forage Sorghum Hybrids

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The use of sorghum hybrids as forage for livestock is increasing. Presently, forage sorghum hybrids make a significant contribution as a summer annual roughage feed in nearly all States of the United States.

Sorghums have been classified according to their utilization and specialized types are recognized. The different classes of forage sorghums have been adequately described by Owen and Moline.[3]

No concise definition for forage quality will fit all forage sorghum types. The breeding effort on sorghum forages has lacked direction and clear objectives and most types that have been developed were selected for plant type and yield without regard to such items as palatability, digestibility and other aspects of nutrition. Forage quality has been a subject of much debate and controversy, but there is general agreement that any sorghum used as forage must possess a potential for high yield of digestible, nutritious feed. A breeder must consider traits such as disease resistance, insect resistance, drought tolerance, seedling vigor, regrowth, standability, maturity and other factors which contribute to overall plant performance in its area of adaptation and utilization. Recent work[2] on nutrition of sorghum grain should lead to a better understanding of genetic diversity in sorghum protein and starch components for disgestibility and efficiency as animal feed. Work of this nature will give direction to breeders.

Breeding techniques have not changed greatly over the years. Mass selection and progeny row methods are still commonly used. Some sophistication in evaluation has been achieved with the use of statistics. Eberhart[1] has suggested a technique for population improvement based on quantitative genetic principles that should theoretically increase the probability of favorable recombinations when multiple characters are considered. This technique has merit in forage breeding work and should facilitate the incorporation of alien germplasm into U.S. material from the World Sorghum Collection. Populations are now being formed by workers in the USDA and this method will be tested.

Breeding objectives are somewhat different for each class of forage sorghum hybrid. For this reason, I have chosen to discuss grass sorghum hybrids and grain-bearing forage sorghum hybrids as distinct groups.

GRASS SORGHUM HYBRIDS

The grassy sorghum hybrids are generally leafy, fine-stemmed types which are used for pasture, greenchop or hay. The vegetative parts of the plant are of prime concern. Three types of hybrids are available: sudangrass x sudangrass; sorghum x sudangrass; and sorgo x sudangrass. Morphological differences between these hybrids are relatively minor and are usually associated with stem and leaf size, tillering or sweetness of the stalks.

The original grass sorghum hybrids were released on the basis of general plant type and yield per acre. Clipping and grazing trials have been extensive by public and private workers in an attempt to establish yield and plant type differences. Usually it is difficult to critically measure significant differences in yield between grass sorghum hybrids. Either significant differences do not exist or the techniques used are not accurate enough to measure these differences. The grass sorghums are repeatedly grazed or clipped and the plants are kept in vegetative growth. One idea that may help to explain the lack of seasonal differences among hybrids is that one measures only the growth rate of hybrids, and this difference is believed to be small (Quinby, personal communications). It may be possible to detect differences among grass hybrids if the crop is cut only once. The user of this product has recognized that hybrids perform differently for traits other than yield. In a recent survey, which polled farmers' opinions on sorghum, it was found that traits such as regrowth, early seedling vigor, protein content, tolerance to herbicides and drought tolerance frequently rank higher than yield as desired traits. Most breeders are aware of these preferences and selections have been made to provide hybrids acceptable for most of these factors.

Forage sorghum breeding has become more specialized. More hybrids are available that have built-in protection for specific areas such as: anthracnose resistance for the Southeastern U.S.; downy mildew resistance for the Southern Coastal States; cold tolerance and early seedling vigor for Northern regions; drought tolerance for dryland areas; and MDM resistance for the Great Plains region.

Recent identification and release of source material for greenbug resistance by Kansas and Oklahoma State Experiment Stations makes it possible to select grass sorghums that carry a field resistance to greenbugs. Resistant stocks for most diseases have also been identified and these stocks are being utilized to advantage. Diseases and insects present a never-ending problem to breeders and work in these areas is continuous.

Reducing the level of prussic acid or hydrocyanic acid in sorghums has been an objective not easily attained. Lower levels of HCN have been isolated, but sorghums devoid of HCN have not been identified. Since conditions causing death by HCN poisoning are variable, it is hard to know what level of HCN in sorghum would be considered safe.

Management procedures affect quality in grass forages. Added nitrogen will increase protein. Proper cutting of stubble will increase and stimulate regrowth. Maturity and stage of growth will change quality and yield. Quality is high and yield low at 30-40" of growth, and the reverse is true with quality low and yield high at maturity. Yield and quality are maximized at, or near, the boot stage of growth. Government regulations on grazing will govern the use of grass forages in some areas. These regulations impose a new dimension making it essential that proper management be employed to achieve best utilization of the hybrid potential of grass sorghums.

The usual breeding approach in grass sorghums considers the many traits required for total performance in a given area of adaptation. Genetic diversity for these traits is being used and selections have been made to meet these objectives. The testing phase of breeding is critical and most programs use an index procedure which allows the best compromise for the large number of traits in which a simultaneous improvement is required. A succession of such compromises will ultimately lead to overall advancement in performance, yield and quality of hybrids produced.

GRAIN-BEARING FORAGE SORGHUMS

The grain-bearing forage sorghum hybrids are represented by tall growing types with lush vegetation and high grain yield. The whole plant is of prime concern to a breeder, and the ultimate of 50 percent stover and 50 percent grain is the desired objective. Basically, combinations between grain sorghums and sorgos are used to make these hybrids. Shorter types (5-7 feet tall) that are high grain producers are commonly classified as dual forage sorghums. Taller sorghum hybrids, usually with a grain component below 50 percent, are used as bundle feed or silage. All of these hybrids may vary in the degree of sweetness of the stalks from dry-stalked types to juicy types. Regular grain sorghum hybrids have been used as forage when high grain and low fiber content are desired; but, for this discussion, these hybrids are not considered as a normal member of this group.

Grain-bearing forage sorghums have uses in addition to bundles or silage that require special features. Utilization as a winter standing hay crop imposes a requirement for exceptional standability after freezing, and later-maturing types are usually desired. Utilization in a multiple cropping scheme employed in some southern regions requires exceptional regrowth and recovery capabilities. Hybrids with these capabilities are available.

A general positive correlation between yield of total dry matter per acre and late maturity exists in sorghum, and late hybrids usually outyield earlier hybrids when moisture conditions are adequate and the growing season is long. Yield of dry matter per acre, plant type and percent grain have been used as criteria for selection. These traits remain as definite requirements for grain-bearing forage sorghums, but nutrition of the whole plant material is becoming more important in the evaluation of these hybrids.

The use of tall sorghums for forage is traditional. This may have been because of the higher sugar content stored in stalks, but the additional height increases the amount of lignin and cellulose in the end product. It is possible to shorten forage hybrids without a loss of leaf tissue since number of leaves is related to maturity and not to plant height. The proper manipulation of height genes found in sorghum will make it possible to reduce forage sorghum heights and lower the cellulose and lignin content of silage without a change in maturity or leaf number.

It is known that sorghum grain in silage is not totally utilized by the animal when fed. Harvesting at higher grain moisture contents and regrinding silage are two techniques that have been tried to better utilize the net

energy of sorghum silage. More detailed work is being done on sorghum grain for digestibility and feeding efficiency. Several papers were presented at the recent Grain Sorghum Producers Association Seventh Biennial Program which considered the many aspects of grain nutrition in sorghums.[3] This work will not be reviewed here, but it suggests much genetic diversity of protein and starch that can be used by breeders to improve overall grain quality in forage sorghums.

As in the case with grass sorghums, an efficient breeding program for grain forage sorghums must be one that can evaluate the many characteristics desired. Traits such as standability, disease and insect resistance, early seedling vigor, cold tolerance and drought tolerance are important depending upon imposed environmental conditions of the area where these hybrids will be grown. In the testing program, some measure of yield, standability, nutrition of grain and stover components and general plant type must be made. The compromise system using a selection index usually provides the best means of picking the hybrid combination which will give the best overall performance for a particular region of adaptation.

In general, breeding procedures are becoming more detailed and specific for forage sorghums. There is a gradual shift away from the plant type and yield concept to a concept of specific adaptation to areas and utilization. In addition, there is greater emphasis on nutrition of the end product. Much improvement will be made in protein and net energy components of sorghum grain and stover. Hopefully, as improvements in the forage product are made, a clear meaning of quality in sorghum forage can be established.

1. Eberhart, S. A. Progress Report on Sorghum Conversion Program in Puerto Rico and Plans for the Future. Proceedings of the Twenty-Fifth Annual Corn and Sorghum Research Conference. December 8-10, 1970, Chicago, Ill.

2. Grain Sorghum Producers Association Grain Sorghum Research and Utilization Conference. 7th Biennial Program, March 2-4, 1971, Lubbock, Texas.

3. Owen, F. G. and Moline, W. F. 1970. Sorghum For Forage Section III, Chap. 8, pages 288-327. Sorghum Production and Utilization, Avi Publishing Company, Westport, Conn.

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Some Aspects of Summer Annual Grass Production

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The purpose of this talk is to discuss some of the aspects affecting the production of summer annual grasses. Many factors are involved, among which are: (1) climatic factors, such as soil temperature which influences success at seeding, ambient temperature which controls growth, and soil moisture, daylength, and night temperatures which may be factors in poor production later in the season; (2) soil or site selection, which has not been given the attention that it deserves; (3) selection of species and cultivar, which will affect and be affected by choice of management scheme, desired output and expected returns; (4) time of seeding, and rate and depth of seeding, which will influence establishment success and perhaps some crop characteristics; (5) fertilizer management, particularly as it involves nitrogen rates and application frequency, which affect growth rate and yield; (6) irrigation, which in some instances has proven beneficial; (7) harvesting management, which influences growth and forage distribution, digestibility and intake; (8) occurrence, concentration and toxicity of dangerous substances, such as prussic acid and nitrate, which may affect intake and use; (9) control of weeds, and of disease and insect pests, which affect production and crop quality; (10) machinery traffic, especially when these crops are harvested under a green-chop system of repeated frequent cuts, which affects regrowth and may decrease desirable soil characteristics.

Soil Temperature

Let us look at the effect of soil temperature on germination. Data from Sumner et al. (16) show that adequate germination took place only when the soil temperature was between 20 and 30 C, and that much poorer germination resulted at lower or higher soil temperatures. This points out the fact that summer annual grasses should not be planted too early, or too late, in the season.

Soil Adaptation

In Tennessee, over the last several years, we have had a total of 36 experiments where soils were paired at each of several locations across the State. The "good" soils are those on which, with moderate to good management practices, high yields of corn can be expected, primarily because of high water holding capacity. The "drier" soils have shallow profiles, fragipans or other characteristics resulting in poorer crop production. The production of corn silage and of Sudax SX-11 was decreased (Table 1) both by planting 6 weeks later (mid-June) than normal (early May) and by selection of the drier soil. On the other hand, Gahi-1 pearl millet was affected much less by these two variables. Thus, there exist substantial species x soil and species x planting date interactions.

Table 1. Effect of soil selection and planting date on the dry matter productivity of corn silage, Sudax SX-11 and Gahi-1 pearl millet in Tennessee, 1964-1969.

Soils	Planting date	Corn Silage	Sudax SX-11	Gahi-1
			T/Ha	
18 "good"	Early May (normal)	16.1	8.3	7.8
	Mid-June	12.6	6.7	6.5
18 "drier"	Early May	12.1	7.4	7.4
	Mid-June	10.3	5.6	6.3

Unpublished data. Fribourg, H. A., G. J. Buntley, F. F. Bell, G. M. Lessman and W. E. Bryan, University of Tennessee.

Growth Habits

We all know that cultivars are widely different in growth habits and performance. This is seen not only by visual inspection but can also be measured. Wedin (19) found that Trudan 2 produced more digestible dry matter (DDM) than other sorghum-sudan hybrids when harvested at a 40-cm height, but that Sudax SX-11 produced more DDM when the harvest was done at dough stage, even though the percent digestibility within each stage was essentially the same for all hybrids studied. The types of plants are very different among and even within hybrids, ranging from long, thin stalks to short, thick stalks, and from very compact heads to open panicles. One would suspect that just as wide a range exists in characteristics of internal morphology, physiology or chemical components. Harvest frequency has a great effect on performance of these grasses, an effect which may not be the same among species and cultivars. For instance, Hoveland et al. (12) noted a gradual decrease in DDM production by increasing the frequency of harvest of Gahi-1 pearl millet from 6 to 4, 3, and 2 weeks, whereas an abrupt decrease of 40% in production was observed as cutting frequency of Funk's 77 was changed from 6 to 4 weeks.

Seeding Rate

Most data reported in the literature (Hoveland et al. (11), Burger and Campbell (2), Matches (13) indicate that smaller yields result only occasionally from seeding rates lower than 10 to 20 kg/ha. Seeding rate effects are usually limited to the first harvest. At seeding rates of about 10/kg/ha or less, culm diameter may be increased 20 to 35%; this can have an effect on drying rate. Burger et al. (3) found that, after 6 days of drying, culms with a diameter of 5.4 mm resulting from a 13 kg/ha seeding rate contained 35% moisture, whereas only 26% moisture occurred in culms 4.3 mm thick resulting from a 54 kg/ha seeding rate.

Row Spacing

The primary reason for wide rows approximating 1 m is historical, i.e., it is related to the width of a draft animal. However, one should consider the damage that grazing animals can do in drilled or broadcast seedings. Burger and Campbell (2) found that increasing row width from 10 to 40 cm had only minor effects on first-growth culm density or culm diameter, and they observed no effects on yields or on plant characteristics later in the season. In an irrigated situation, Sumner et al. (16) found little difference due to increasing row spacing from 30 to 90 cm, although the 45-cm spacing tended to result in greater dry matter yields. We have obtained similar results in Tennessee.

Traffic

Sumner (15) found a 22% decrease due to running a tractor wheel once, on three occasions, over a sorghum-sudan hybrid row. In Tennessee, we have studied this effect since 1967. The data (Table 2) indicate a 20% decrease in production if the tractor wheel traveled over the row of Sudax SX-11 or Gahi-1 pearl millet at each harvest; an additional decrease resulted when the tractor was followed by chopper and wagon wheels on Sudax SX-11.

Table 2. Effect of wheel traffic on dry matter production of Sudax SX-11 and Gahi-1 pearl millet, Memphis silt loam, Jackson, Tennessee, 1968-1970.

Traffic at each harvest	Sudax SX-11	Gahi-1
	T/ha	
None	7.2	6.3
Tractor	5.8	4.9
Tractor + chopper + wagon	4.9	4.9

Unpublished data. Fribourg, H. A., J. R. Overton and J. A. Mullins, University of Tennessee.

Not only yield was affected, but soil bulk density was increased by traffic (Table 3). Our observations indicate, however, that the primary damage is to culms, upper roots and meristematic areas of the plants.

Table 3. Effect of wheel traffic on bulk density of Memphis silt loam. Jackson, Tennessee, 1969.

Traffic at each harvest	Bulk density 0-4 cm Before first harvest	Bulk density 0-4 cm After last harvest	Bulk density 6-10 cm Before first harvest	Bulk density 6-10 cm After last harvest	Elevation loss, cm
None	1.25	1.38	1.42	1.40	0.5
Tractor	1.33	1.50	1.38	1.41	4.0
Tractor + chopper + wagon	1.25	1.58	1.39	1.49	5.1

Unpublished data. Fribourg, H. A., J. R. Overton and J. A. Mullins, University of Tennessee.

Fertilization

There is little information in the literature about the effects on summer annual grasses of fertilizer elements other than nitrogen. Nitrogen fertilization, however, is dramatic in its effects. For example, Sumner et al. (17) and Broyles and Fribourg (1) have found that yield responses are directly proportional to N up to about 200 kg/ha. Yields leveled off for Sumner et al. when additional increments of 100 or 200 kg/ha were applied. Forage nitrate content was within the "safe" zone up to 200 kg/ha of N, but approached possible toxic concentrations at higher N fertilization rates (6).

Weed Control

Occasionally, weed control problems occur in summer annual grass stands. Unfortunately, only three compounds, 2,4-D amine, propazine and atrazine, are cleared partially for use with these crops; even then, restrictions exist when grazing is the harvest method. Application methods and rates are dependent on soil and climate, and since restrictions change frequently these days, one should consult a current label prior to using any pesticide or herbicide.

Harvesting Management

What is the best harvest management to obtain a well-distributed, high yield of highly digestible and nutritious forage which will be eaten in large quantity by ruminant animals? The genetic constitution will interact with the management to which the plant will respond. A thick-culmed sorghum-sudan hybrid, just like Gahi-1 pearl millet, does not recover as rapidly after cutting as a thin-culmed hybrid. A thin-culmed hybrid can tolerate closer grazing or cutting than a thicker-culmed one. Stubble height, and height or stage of growth when harvested, influence not only total dry matter or digestible dry matter yields, but most particularly leafiness. Tennessee data

show that Gahi-1 pearl millet 50-cm growth cut to a 2.5-cm stubble yields 7 T/ha containing 40% leaf, whereas 75-cm growth cut to a 25-cm stubble yields 14 T/ha containing 90% leaf. The percent of apical meristems removed is inversely related to stubble height. These observations have been confirmed by Clapp and Chamblee (4). These relationships affect not only total production, but also the distribution of this production during the season, since higher stubbles tend to shift production to later periods in the summer. Clapp and Chamblee showed that low stubbles are more detrimental to some cultivars than to others. It is clear, however, that regrowth must come from adventitious meristems, from either nodes or culm bases. Generally, the higher the stubbles are, up to a point, the more vigorous and leafy is the regrowth. It has been thought that the carbohydrate content of stubble should be related to regrowth in summer annual grasses, just as it is in perennial grasses and legumes. However neither Couch (5) nor Holt and Alston (9) found this to be the case. The latter found no relationship between stubble carbohydrate content and yield, nor was there any re-storage after the first cut.

Digestibility and Animal Intake

Since forages are grown to supply animals with feed, the information available on digestibility and voluntary intake is of paramount importance. Van Keuren et al. (18) compared summer annuals with alfalfa in a digestibility trial and found that dry matter and protein from two of those grasses, harvested at 75 cm of growth, were just as or more digestible than dry matter or protein from alfalfa harvested at the bud stage. Edwards, Fribourg, and Montgomery (7) concluded, on the basis of several years of data, that: (1) the growth rate of Sudax SX-11 decreased with the number of cuttings and as the season progressed; (2) the total dry matter and digestible matter production were greater for more mature plants than for more vegetative plants; (3) the leafiness was more related to stage of growth and plant height than to time elapsed since a previous harvest; and (4) percent digestibility was more related to plant height and morphological characteristics than to time since a previous cutting. In a subsequent study, Fribourg, Duck, and Culvahouse (8) have shown that the digestibility of leaf or stem material from either Trudan 2 or Sudax SX-11 remained constant at a high level throughout the season, as long as management practices were such that plants were maintained in a vegetative and vigorously-growing condition. It is generally recognized, however, that high forage digestibility is of little value unless the animals consume the plant material. Rabas et al. (14) have shown a surprisingly wide range of consumption by cattle and sheep for a number of summer annual grass cultivars. In a 4-day cafeteria experiment, cattle consumed as much as 52% of a standing crop of Piper sudangrass, while consuming only 7% of the Sudax SX-11; for sheep, the consumption percentages were 80 and 31, respec tively. Lower consumption values were associated with cultivars high in prussic acid content.

Needs for the future

As I see it now, our needs for the immediate future are:

1) More information on the factors affecting animal intake of summer annual grasses managed in different ways.

2) Plants which maintain, throughout the season, a high proportion of leaves to stems and inflorescences, and which tiller profusely.

3) Plants which re-grow well when the soil is dry, when daylengths are shortening, and when night temperatures are low, in order to extend the season of vigorous growth into late summer and early fall.

4) An evaluation of cropping systems where greater use can be made throughout the year of land where annual grasses are grown in summer. Consideration should be given to cool-season annual plants planted in the stubble of warm-season plants, and vice-versa; and to seeding summer annuals in sods of cool-season perennials, as has been suggested by Hoveland (10).

5) Information on the factors affecting the activity of toxic principles, such as HCN and NO_3^-, and the development of research techniques which can reliably control the onset of poisoning.

6) More specific, safe and season-lasting weed control.

7) Plants with more disease resistance, specifically adapted to the warmer and more humid regions of the country.

8) Finally, the development of prediction models relating climatic parameters, soil properties, plant specifications, animal characteristics and management influences with output, i.e., animal production per unit of input.

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Pros and Cons of the Utilization of Summer Annuals in a Beef Cattle Program

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Less than 10 years ago I could have given my talk on the above subject in one sentence, "We do not use summer annuals in a beef cattle program." This has changed in recent years due primarily to the changes in our overall beef cattle program. Summer annuals are expensive and, in most cases, can not be used to support the beef cow. It must be used in programs where all the products produced can be sold. The summer annuals lend themselves to a specialized type of program since they are usually higher in quality than is needed for the beef cow.

I invite you to go back with me for a few moments and review what has happened to the beef cattle industry in the past decade in the South. Not too many years ago, we were producing "feeder calves" that were purchased by the so-called wheat farmers of the West and mid-west in the fall when the calves were weaned at about 300-350 pounds. Due to research and education by our extension leaders, this is changing rapidly throughout the South. We are seeing many of our calves being kept and grown on high quality forages and then sent to feed lots either out west or in the immediate area where they were produced. The high quality summer annuals are being used in this program.

Species

There has been a large number of species and varieties of different summer annuals available in the past 10 years. The hybrids of the sudans and millets which have been discussed previously have played an important role in changing our philosophy of beef cattle production. These plants have both quality and quantity which are essential in todays agriculture. The annual lespedezas are beginning to play an important role in certain of the beef production programs. Grain sorghum (milo) is another species that must be mentioned.

Methods of Utilization

The summer annuals as mentioned before must be utilized so that the total product can be sold. This limits its use to the growing of beef calves. There has been some interest recently in "creep grazing" where a small

percent of the alloted acreage per cow-calf unit is seeded to one of the sudans or millets and grazed only by the calf. This method will work where you have a poor quality pasture for the cow to graze. There is no benefit to be derived from this method of utilization if you maintain a good grass-legume pasture for the cow. We are using the summer annuals; sudans, millets and annual lespedeza, to grow our calves during the summer months following weaning in late June. We have found that it is almost impossible to maintain an acceptable daily gain if we leave the calves with the cows during July, August, and September. Many years we have just mtaintained the calf weights or even lost weight during these months. We are calving in October, November, and December so that we can wean by July 1. These calves are put on one of the summer annuals and kept throughout the summer. We are getting daily gains of around 1.25-1.75 pounds using this system. We practice rotational grazing on all species. Our fertilization program is determined by our forage needs and is based on production to carry a minimum of four calves per acre. Another program that looks good to us is the seeding of grain sorghum in tall fescue-white clover sod. The grain sorghum is allowed to produce seed which is harvested and the refuse plus the fescue-clover is used to winter or background calves.

There are probably many other ways to utilize the summer annuals in a beef cattle program. I feel that their importance will increase in our area as we increase weaning weights and especially if and when we become interested in producing cattle of slaughter weight and grades.

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Role of Summer Annuals in a Dairy Forage Program

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A survey of researchers and a review of the literature on this subject in the southern region revealed a greater than usual range of positions with regard to the role summer annuals might play in a dairy forage program. Positions, all based on research conducted in the various states, ranged from one concluding that "since the maintenance of a high level of production is of such importance in today's herds, we hesitate to recommend summer annuals with their problems in maintaining digestibility, intake and overall quality" to one stating "we would find it extremely difficult to maintain an acceptable level of production without the use of summer annuals for grazing and/or green chop." As a researcher in forages I find it easy to understand how these individuals arrived at relatively opposite positions on this subject.

Because of this wide range in findings, I have elected to report only on research results obtained at the Louisiana Dairy and Pasture Experiment Station, Franklinton, Louisiana. Additionally, I have elected to omit corn, a widely used and excellent summer annual, except for comparative purposes. I shall further handle the assignment in two parts, that is, summer annuals utilized as silage and summer annuals utilized as a grazing forage.

Summer Annuals for Silage

Determining the optimum stage of growth, direct cut, at which to harvest such summer annuals as millet, Sudangrass, the sorghum-Sudan hybrids and Johnsongrass represented the initial problem. Millet was the specie selected for making this determination. Percent dry matter and crude protein increased, while percent crude fiber decreased as stage of growth advanced from boot to hard dough. Dry matter preservation during the ensiling process increased markedly as stage of growth advanced. Adding 150 pounds of ground shelled corn per ton of green material at the time of ensiling, increased the dry matter content five percentage units for each stage tested. Crude protein content was also increased, but only slightly, while crude fiber content was reduced four percentage units by the addition of corn meal. Dry matter preservation during the ensiling process was increased from 67% to 76% and from 88% to 92% as a result of the addition of corn to millet harvested in the boot and soft dough stage respectively.

Pounds of dry matter intake per 1,000 pounds body weight decreased from 17.7 pounds to 17.0 respectively for direct cut boot and soft dough millet. The addition of 150 pounds of corn at the time of ensiling increased the dry matter intake for both silages to 18.5 pounds per 1,000 pounds of body weight. If the pounds of 4% fat corrected milk produced by corn silage were expressed as 100, the milk production of boot, and soft dough millet without and with ground corn would be 99.9, 94.3, 111.0, and 105.2 respectively.

These data generally indicate that the boot stage of growth is the most desirable stage for harvesting these crops and that the addition of ground corn at time of ensiling is beneficial. The question arises, however, does corn improve the total ration, or does it actually improve the silage. To answer this question, the equivalent amount of corn added at time of ensiling was added to the silage at the time of feeding. Boot millet, to which 150 pounds of ground corn was added at time of filling, was five percentage units lower in dry matter, .4 percentage units lower in crude protein and five percentage units higher in crude fiber than boot millet to which the equivalent amount of corn was added at filling time. Silage intake was increased 2.5 pounds per 1,000 pounds body weight by adding the corn at time of feeding. Milk production, expressed as a percentage of corn silage was 95.5 and 99.7 respectively for boot millet, plus corn at time of filling and boot millet plus the equivalent amount of corn at time of feeding. These data indicate that the principal beneficial effect of adding corn is to improve the ration rather than to improve the silage.

The hybrid forage sorghums represent another category of summer annuals for silage. The optimum stage of growth for harvesting is one problem. To answer this question, a hybrid forage sorghum was harvested in the boot, milk and hard dough stages of growth, ensiled and fed free choice to lactating dairy cattle. Percent dry matter increased, percent crude protein and crude fiber decreased, and percent dry matter preserved during ensiling increased in a straight line linear fashion as stage of growth advanced. Additionally, there was a linear increase in milk production as stage of growth advanced.

In order to provide specific information on the effect of the ratio of grain to forage in a sorghum silage, a combine milo was compared with a hybrid forage sorghum. The combine milo was higher in dry matter and crude protein, lower in crude fiber and eleven percentage units lower in dry matter preservation than the hybrid forage sorghum. The combine milo, however, was 11.4 percentage units higher in milk production than the hybrid forage sorghum. In studying the increase in milk production, one must conclude that the nearer the ratio between forage and grain approaches 50:50, the greater will be the similarity between milk production of corn silage and sorghum silage.

After experiencing an apparent lower milk production from sorghum silage harvested with a "flail" harvester as compared to this same crop harvested with a conventional "sickle bar" machine, an experiment was initiated to determine if this experience was real. The study revealed that the milk production of flail harvested sorghum silage was eight percentage units lower than the same silage harvested with a conventional sickle bar machine set for a one-half inch theoretical cut. The difference was probably due to the fact that the flailing action of the flail machine ruptured the plant cells to such an extent as to cause the cell wall constituents to be increased from 53.2% for the conventional cut to 57.8% for the flail cut. This, of course, means that the various fiber constituents were greater for the flail cut than for the conventional cut, thereby reducing milk production per cow.

In order for farmers to make a decision as to which silage is economically to his advantage, he must know many things. He must know the green yield per acre and the dry matter preserved or lost during the ensiling process in order to determine the yield per acre of feedable silage and the cost per ton of feedable silage. Additionally, he must know the pounds of silage on an "as fed" moisture basis his cows will consume free choice. He must further know the relative milk-producing potential of this silage when fed on a free choice basis. Armed with these four bits of information - yield per acre, dry matter preservation, intake and milk production - the farmer can make a decision as to which silage is best for him.

Summer Annuals for Grazing

First, we should establish the fact, if we can, that annuals have a role to play when utilized as a grazing forage by lactating dairy cattle. To do this, a study, designed to compare millet, a summer annual, with bahiagrass, a summer perennial, was conducted. This 3-year study, an average of 170 days grazing each year, provided a per acre carrying capacity of 1.48 and 1.80, an average daily milk production of 38.6 and 44.1 and a return overall feed cost of $299.42 and $328.66 respectively for bahiagrass and Gahi millet. Butter-fat and solids not fat of the milk were unaffected by forage. Millet, a summer annual, while expensive to produce and difficult to manage when compared with bahiagrass, a summer perennial, produces a forage of sufficiently high quality to enable lactating cows to produce a sufficiently large amount of milk to more than offset the increased cost of producing the forage.

Thus, it would appear that a summer annual has a role to play in a dairy forage program. The question then becomes one of determining which summer annual is superior. In grazing trials over the past 10 years, Gahi millet has been much superior to other varieties of millet, the Sudan varieties, the johnsongrass hybrids, the Sudan hybrids, and the sorghum-Sudan hybrids. In one test, for example, Gahi millet carried 2.7 mature Holstein cows for 60 days, producing a total of 5,415 pounds of milk per acre. The best record for a sorghum-Sudan hybrid was a carrying capacity of 2.2 Holstein cows per acre for 60 days, producing 4,125 pounds of milk per acre.

In tests designed to determine the grazing management that should be imposed on a summer annual, Gahi millet and a sorghum-Sudan hybrid were grazed in such a manner as to maintain forage heights between 6" and 18" and between 18" and 36". Gahi millet was superior to the sorghum-Sudan hybrid in both management systems. The management regime giving the best results was one in which the rotation program provided that grazing would commence when the forage was 18" high and cease when grazed to a 6" stubble.

The literature is somewhat voluminous with regard to tests comparing strip, rotation, and zero grazing of summer annuals. It appears that the management procedure that will determine which system is better, or whether there really are any differences, is whether or not the researcher conducting the study manages or otherwise controls the study to the extent necessary to see that

forage provided by all or any treatments remains continuously in a vegetative stage. If the forage in a zero grazing or green chop method of utilization remains in the same stage of growth as the strip or rotation system the zero or green chop will always be superior to strip or rotation because the zero system provides for complete utilization of the forage produced. If, on the other hand, the zero or green chop forage is allowed to proceed toward maturity, while the management inherent in the strip or rotation system maintains the forage in a vegetative stage, milk production of a zero grazed summer annual will rapidly decline at the time seedhead emergence from the boot commences.

Summer annuals, in the judgment of this author, have a tremendously important role to play in a dairy forage program. As a matter of fact, when one considers the alternative perennial species that are available, and their relatively inherently low quality, it is difficult to imagine a dairy forage program wherein summer annuals do not play the dominant role. To me, the question is one of how will we use these summer annuals in our total forage program, not whether they have a role to play. The role is obvious, dairy farmers in our region cannot exist without summer annuals. The question we must answer is how can the dairy farmer use summer annuals most advantageously and the answer will very likely not be the same for all dairy farmers.

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245

Prussic Acid (HCN) Potential of Sorghum and its Effects on the Animal

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Species of the sorghum family (Sorghum sp) have the unique characteristics of enduring both the heat and drought of summer. Consequently, they provide lush grazing or desirable silage, while many of the perennial cool season forages are dormant or not productive. This one characteristic has probably been mainly responsible for sorghums' widespread use throughout the United States. Their acceptance has occurred in spite of its potential to cause prussic acid or hydrocyanic acid (HCN) poisoning. The acreages seeded annually to this crop would probably be even greater if HCN poisoning were not in question.

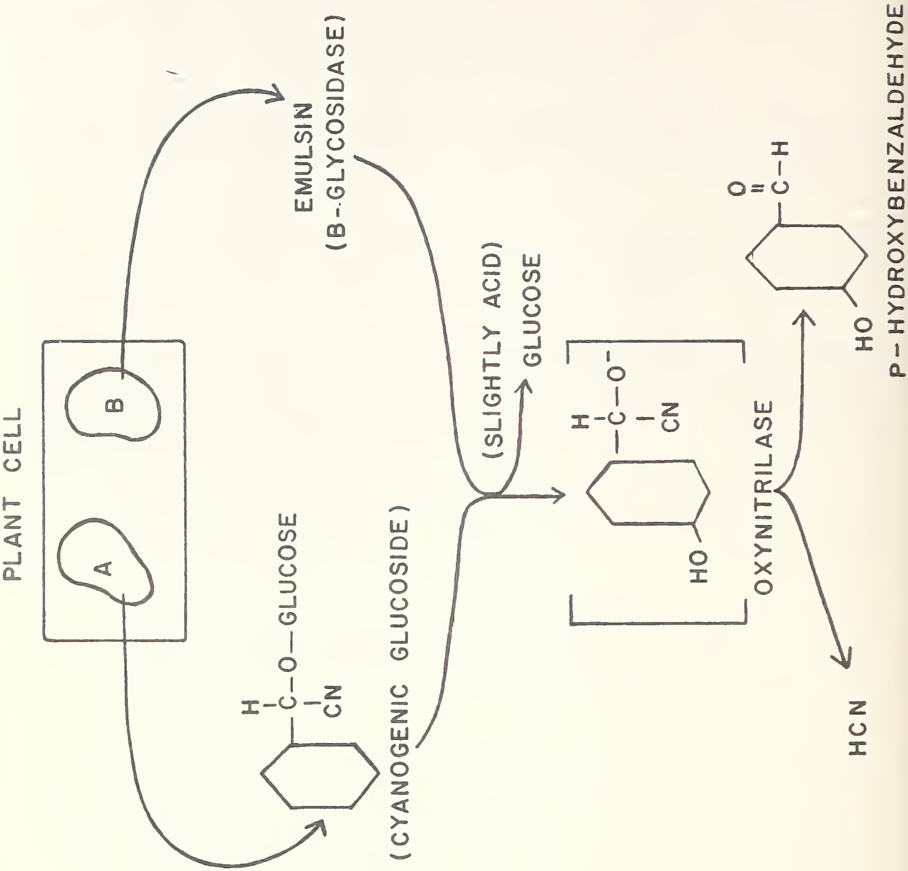
The losses in livestock numbers (or in dollars) from HCN poisoning must be small if one considers the value (numbers or dollars) of the cattle industry in total, probably of lesser magnitude than that from bloat. However, certain regions of the country appear to be problemed more by HCN poisoning than are others. It is within these regions that the problem becomes more acute. Obviously, if a producer loses 10 to 20% of his cattle to this plant, he is quite aware that he has a problem. His losses are critical to him, and in fact, can be devasting to his enterprise regardless of how small his losses may appear compared with the worth of the total cattle industry. Consequently, time is warranted to consider information available on HCN toxicity of sorghums.

Liberation of HCN from Plant Tissue

Prussic acid (HCN) is not present as such in healthy sorghum plants. It is only in terms of the HCN potential that one should discuss the possible toxicity of sorghum grasses.

In explaining the liberation of HCN from plant tissues it requires moving from the whole plant to the cellular level. Within each cell and compartmented away from other cellular constituents is a compound, characteristic of sorghums, called a cyanogenic glucoside. This compound, frequently referred to as dhurrin, consists of a benzene ring with a carbon attached and linked via oxygen not only to a hexose sugar (glucose) but also to a cyanide (CN^-) radical (figure 1). Within the same cell, but compartmented away from the glucoside, is an enzyme called emulsin (B - glycosidase). Upon destruction of the cell structure, the cyanogenic glucoside and emulsin are set free and consequently, come in contact with each other. Under slightly acidic condition (normally present in plant cells), the oxygen linkage is cleaved and glucose along with the remaining intermediate is released (figure 1). The action of oxynitrilase upon the intermediate compound produces parahydroxybenzaldehyde and HCN.

It is appropriate at this time to point out that similar conditions exist in the rumen of ruminant animals (cattle and sheep). Forage has been


PLANT CELL
A
B
EMULSIN
(B-GLYCOSIDASE)
H-C-O—GLUCOSE
CN
(CYANOGENIC GLUCOSIDE)
(SLIGHTLY ACID)
GLUCOSE
H-C-O⁻
CN
HO
OXYNITRILASE
O
C-H
HO
P-HYDROXYBENZALDEHYDE
HCN

well-masserated. The pH is slightly acidic and emulsin is present in large amounts. Also, the temperature is ideal for enzyme activity. This all results in a very conducive environment for HCN liberation.

Fate of Released Prussic Acid (HCN)

<u>Release in the field</u>:

Where sorghums have been mowed, crimped and permitted to cure for hay or oven-dried or ensiled as much as 72% of the HCN potented has been reported lost to the atmosphere (4). Such treatment greatly reduces the possibility of livestock poisoning.

<u>Release in the rumen</u>:

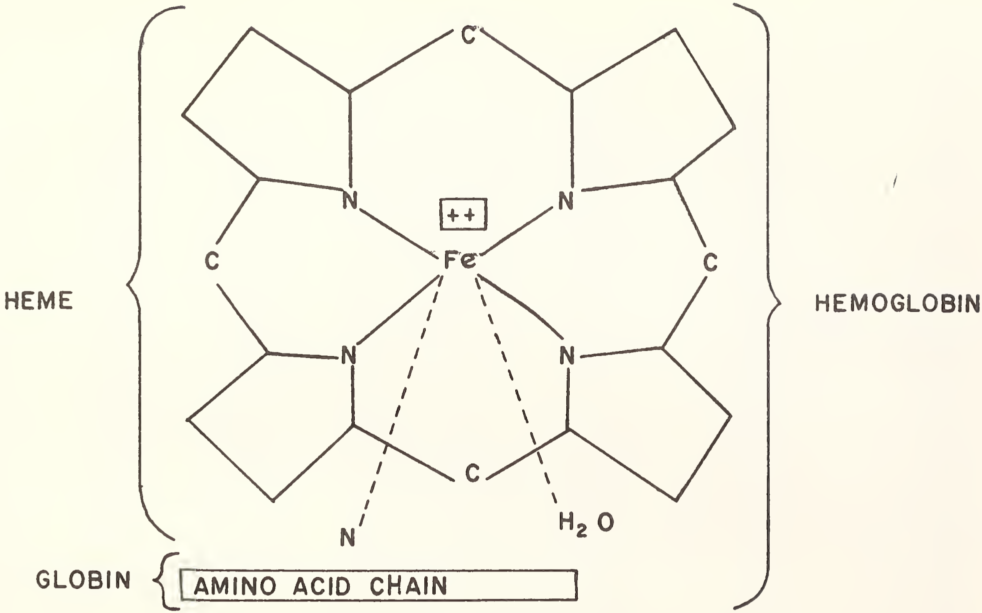
When sorghums are grazed by ruminant animals, HCN is released in the rumen. The HCN is absorbed into the blood stream and can circulate to all parts of the body. Several early theories, as well as a recent concept regarding the mechanism of HCN poisoning are described below.

To assist in explaining the early theories figure 2 was constructed showing the overall structure of hemoglobin. Four porphyrin rings are bonded to iron compsoing the "heme" portion of hemoglobin. A specific amino acid chain consisting of peptide bonds form the protein (globin) portion of hemoglobin. The globin portion when linked to the iron in the heme forms hemoglobin. A sixth bond from iron is associated with either H_2O, as in hemoglobin; O_2, as in oxyhemoglobin; CO, as in carboxy-hemoglobin; CO_2, as in carbamino compound; and NO_3^-, as in methemoglobin depending on concentration and affinity of these compounds for iron.

In the first early theory, cyanide (CN^-) was thought to occupy the position of H_2O in hemoglobin (figure 2) and compete successfully for the O_2 site in oxyhemoglobin (figure 2). Oxygen transport was then reduced. There was no exchange of oxygen between the blood and animal tissue and asphyxiation (suffocation) resulted at the cellular level.

In a later theory it was thought that cyanide (CN^-) did not occupy the site of O_2 in oxyhemoglobin as only iron in the ferric state (Fe^{+++}) could accept cyanide but rather cyanide inhibited the enzyme that released O_2 from the oxyhemoglobin (figure 2). If such occurred, asphyxiation at the cellular level would again result.

At the present time it is believed that the cytochrome oxidase system (election transport system) found in all living cells is the site of HCN poisoning (figure 3). Reduced nucleotides transfer hydrogen to flavoproteins (figure 3-a), an electron is then transferred to cytochrome where ferric iron (Fe^{+++}) is reduced to ferrous iron (figure 3-b) and finally the electron is transferred to cytochrome oxidase, the terminal cytochrome (figure 3-c). At this point the hydrogen (carried along in solution) is recombined with oxygen and the electron to produce water (figure 3-d). The



REPLACE H_2O BY O_2 — OXYHEMOGLOBIN (Fe^{++})
REPLACE H_2O BY CO — CARBOXYHEMOGLOBIN (Fe^{++})
REPLACE H_2O BY CO_2 — CARBAMINO COMPOUND (Fe^{++})
REPLACE H_2O BY NO_3 — METHEMOGLOBIN (Fe^{+++})

Figure 2. Overall structure of hemoglobin and replacement of H_2O by O_2, CO, CO_2, and NO_2.

ELECTRON TRANSPORT SYSTEM

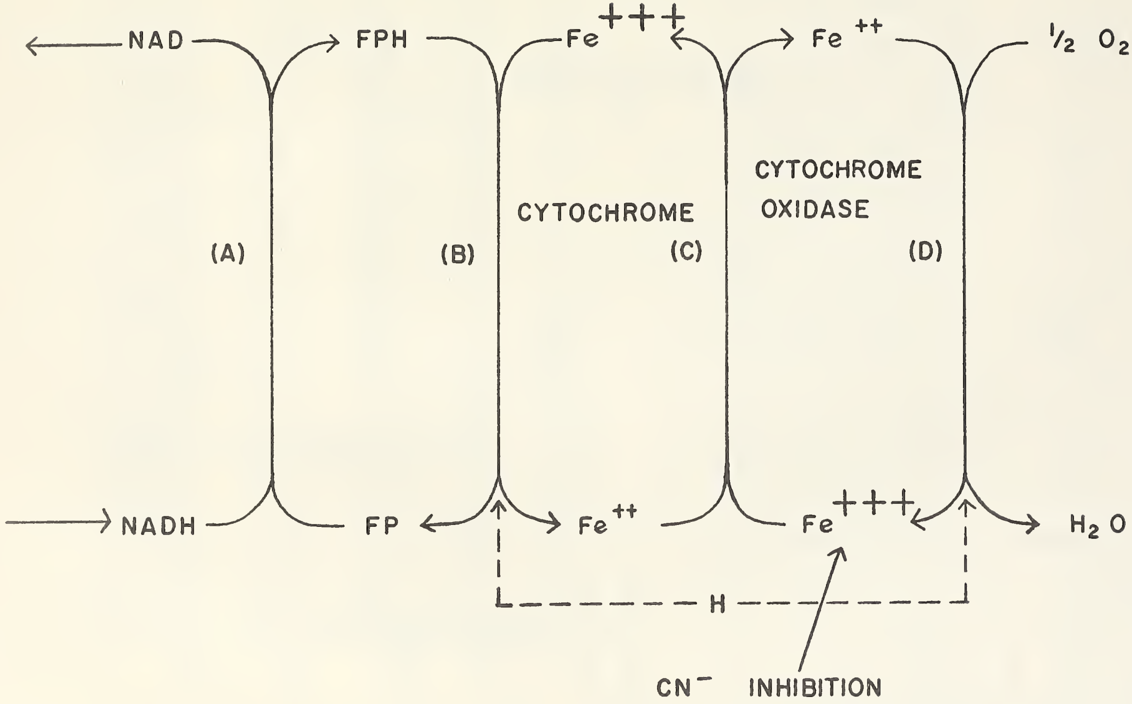


Figure 3. Electron transport system showing the cite of CN^- inhibition.

terminal oxidase has iron in the proper state (Fe^{+++}) to accept cyanide and has been found to be unprotected to the action of CN^-. Consequently, in cases of HCN poisoning, the terminal oxidase is complexed with CN^-. This results in complete breakdown of the cell function and life processes cease to continue.

Treatment for HCN Poisoning

Methylene-blue has been widely used in the treatment of HCN poisoning. The mechanism of action relates back to the early theory previously mentioned regarding the influence of CN^- on the oxidation state of iron in hemoglobin. Researchers have found that the iron in hemoglobin must be oxidized to the ferric state (Fe^{+++}) before CN^- will replace oxygen in oxyhemoglobin. The administration of methylene-blue accomplishes this conversion resulting in an increase in methemoglobin and the subsequent pickup of CN^- from the animal tissue (figure 4). Although CN^- inhibition of the electron transport system has now been removed, there is a high level of methemoglobin. To prevent the accumulation of methemoglobin Sodium thiosulfate ($NA_2SO_2O_35H_2O$) is administered and the thio-cyanide salt is produced which is readily filtered out through the kidney and excreted in the urine.

Factors Influencing Potential HCN Levels in the Plant

<u>External Factors</u>:

(1) Availability of nitrogen;
Researchers generally find increased levels of HCN associated with increased levels of nitrogen.

(2) Nitrogen to phosphorus ratio;
Plants receiving high nitrogen and low phosphorus tend to release higher levels of HCN.

(3) Drought or cool weather;
Plants generally show increased release of HCN under drought or cool weather conditions. In either case growth is reduced and the HCN potential increases.

(4) Lack of nutrients;
Plants generally show reduced release of HCN where nutrients status of the soil is low.

(5) Frosted plants;
Freezing results in a breakdown of plant tissues and production of HCN; however, upon thawing and wilting, the levels disappear very rapidly. After freezing and under suitable weather conditions, new growth is often initiated. This lush material is generally high in HCN release.

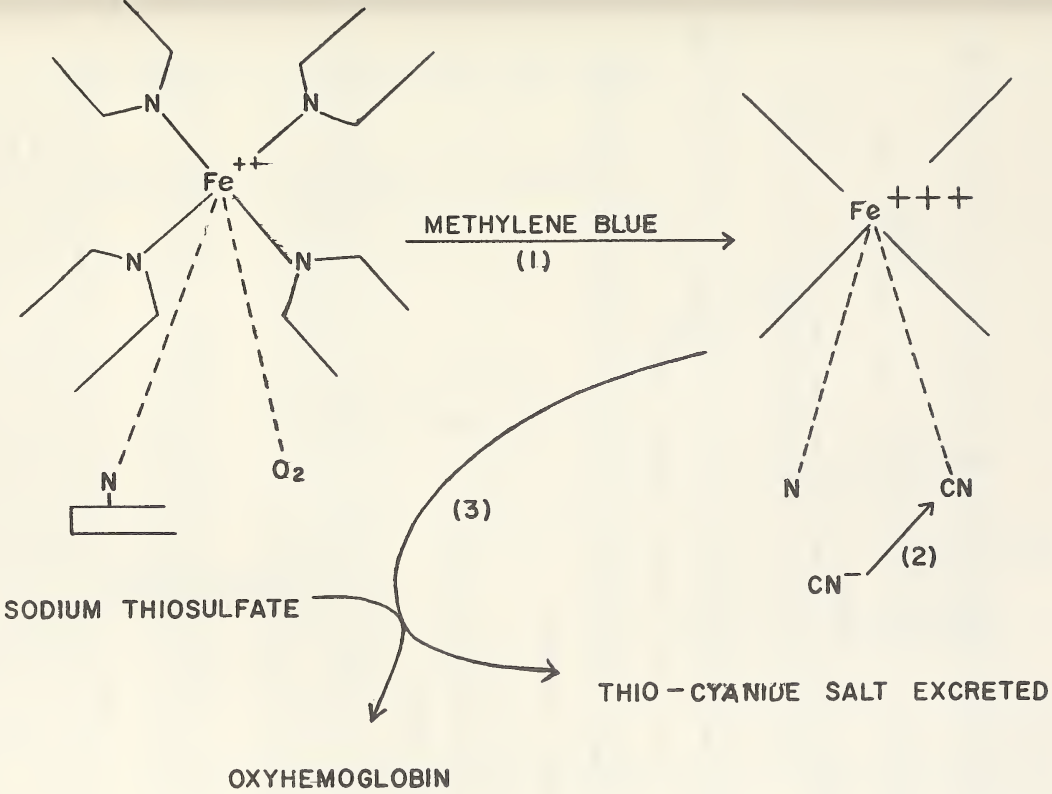


Figure 4. Treatment for HCN poisoning: (1) Conversion of oxyhemoglobin to methemaglobin, (2) removal of CN^- from body tissue by methemoglobin, and (2) formation of oxyhemoglobin and excretion of CN^- as the cyanide salt.

Internal Factors:

(1) Photosynthetic rate;
Generally plants have increased HCN release as the photo-activity of the plant increases (mainly between 8-10 a.m.).

(2) Hereditary;
Varietal differences in potential HCN release may be very large.

(3) Immature plants vs mature plants;
Immature plants are higher in HCN release than more mature material. This is associated with reduced photosynthetic activity in the leaves along with a dry matter dilution effect.

(4) Plant stems vs plant leaves;
Leaves consistently show from two to 25 times more HCN release than stems.

Metabolic Function of the Cyanide Containing Glucoside

The exact function of the cyanogenetic glucoside in plant metabolism remains obscure. However, several theories have been set forth (11, 14). These are:

(1) Excretionary substance

(2) Protective substance

(3) Precursor of protein synthesis

(4) Storage substance

It is possible to find data that will support, to varying degrees, each of the above theories. For example, Rabas et al. (13) noted a significant negative correlation between HCN potential of sorghum x sudangrass hybrids and palatability. One could rationalize that the HCN potential of the plant served as a protective factor. However, it appears that theories 3 and 4 play the key role (6, 11, 14).

Isotope trace studies have shown that the nitrite carbon atom of the glucoside is derived from the carbon of L-tyrosine. The aromatic ring and the adjacent carbon atom of the aglycone are formed from the B-carbon atom and the ring of L-tyrosene (5, 10).

One can speculate that under conditions of excess available nitrogen that NH_4^+ is readily formed via the nitrate reductase system, and can combine with keto acids to form an amino acid pool (figure 5). Amino acids can then be used as building blocks for plant growth or other metabolic processes. Under such favorable conditions tyrosine can be withdrawn from this pool, rearranged, and with the addition of glucose, form the glucoside, dhurrin (figure 5). This reasoning is partially supported by data

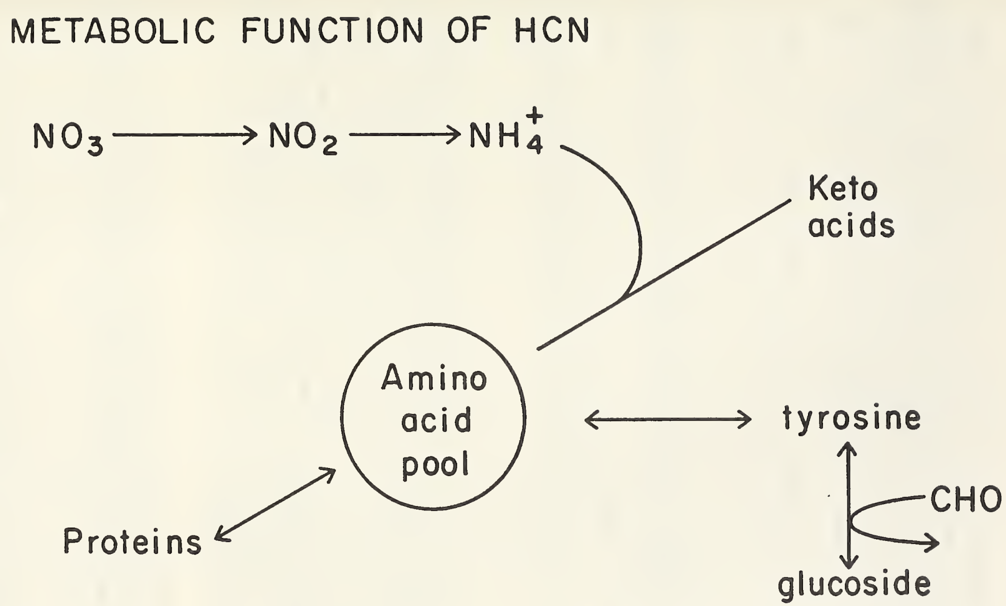


Figure 5. Proposed interrelationships among NO_3 availability, amino acid pool and glucoside levels.

regarding the influence of 2,4-D applied on sorghums. Swanson and Shaw (15) noted that 2,4-D applications caused large increases in NO_3^- concentrations, and subsequent reductions in the glucoside level. Since the site of action of 2,4-D is the nitrate reductase system, one could again speculate that with the blockage of N for amino acid synthesis that tyrosine (from the glucoside) moves back into the amino acid pool to be used in metabolism, thereby, reducing the level of the glucoside.

Factors Influencing Animal Capacity to Tolerate HCN Release from Plant Tissue

Rate of Intake:

Rate of intake is commonly thought of in terms of daily dry matter requirements. It is normal in determining intake for a certain period of time to ascribe a certain percentage of the total daily dry matter requirement to that time period.

In considering toxic levels of HCN release from sorghums this reasoning should not be used. It is not dry matter that causes animal death, but rather the concentration of HCN liberated from each unit of green forage consumed.

This principle is supported by research at Wisconsin where no relationship was found between percent dry matter and potential HCN production (12). To further point this out, dry matter levels can vary from 15-30% in summer-cut forage. This, of course, is dependent on cutting frequency and weather. With such a wide range in dry matter content large differences in the quantities of green forage consumed will be required to obtain equal amounts of dry matter intake. In forages with high moisture and high HCN potential toxic levels may occur after an animal has eaten only half the amount of dry matter compared to an animal consuming forage with low moisture and high HCN potential. The producer must be concerned with the quantity of HCN consumed per unit time, which means HCN consumed per mouthful of forage.

Selective Grazing:

Grazing of leafy material will generally result in higher HCN release in the rumen per unit of forage consumed compared to stems or to a leaf-stem mixture.

Animal Size:

The larger the animal the more HCN is required to saturate the system.

Detoxifying Capacity of the Animal:

Some animals, as compared to others of equal size, have the capacity to excrete in the urine rather large amounts of CN^-.

Toxic Levels - Concentrations in the Plant and Dosage in the Animal

Having listed nine major plant factors that may alter the HCN potential of the plant and four animal factors that may alter the toxicity of liberated HCN, it is understandable why a critical plant level above which HCN poisoning will occur, is not well-defined. However, there are some guides which appear reasonable and can be useful as a "rule of thumb".

From the plant viewpoint, Kingsbury (9) suggested 20 mg of HCN per 100 g of fresh plant tissue would provide a lethal dose. Boyd et al. (1) suggested 1 g of HCN per 1,000 lb of body weight as a fatal animal dose. He conditioned this based on the detoxifying ability of the animal.

Table 1 shows a range of HCN concentrations in both sudangrass and forage sorghum along with the pounds of green forage required to achieve a fatal dose.

Table 1. Range in HCN concentration and pounds of forage required for fatal dose. (From H. N. Finall [16]).

Crop	(HCN) (%)	Lb of forage for fatal dose
Sudangrass (9 harvests, variable ht)		
Range	0.002 to 0.015	59.6 to 8.1
Average	0.007	18.9
Sorghum (5 harvests, 30" ht)		
Range	0.013 to 0.023	9.6 to 5.5
Average	0.020	6.6

In more recent studies Burns et al. (2) reported forage sorghum harvest as pasture (simulated) to be quite high in HCN (over 20 mg/100 g of tissue) prior to frost with levels decreasing after frost. Piper sudangrass contained low concentrations (3 mg/100 gm sample)throughout the study. In forage-managed hay (one summer cut) the leaves of sorghum averaged 26 mg of HCN/100 g fresh forage prior to frost and again decreased after frost. Sorghum stems, like Piper, contained quite low levels of HCN. According to the "rule of thumb" proposed by Kingsbury, both the sorghum leaves and the whole plant would represent a source from which an animal could obtain a lethal dose.

To equate the plant level suggested (20 mg HCN/100 g forage) causing

toxicity in the animal to the level suggested to be fatal in the animal (1 gm HCN/1,000 lb of body weight), some calculations were made based on the following assumptions:

(1) 1,000 lb animal.

(2) No detoxification of HCN by the animal.

(3) The animal consumed 10-15 lb of forage in the first 15-20 minutes of grazing.

(4) 1 g HCN per 1,000 lb of body weight is toxic.

At 20 mg HCN/100 g of fresh forage, the animal would consume 1 g of HCN in 11 lb of forage. At 4 mg HCN/100 g of fresh forage (approximate levels found in sudangrass) an animal would consume 1 gm of HCN in 55 lb of forage.

The levels of intake required to cause toxicity from forage sorghum can easily be achieved within the time limit above, while the intake required for toxicity from sudangrass represents essentially a full day's feed. The plant concentration and animal dose suggested as being critical appear in agreement and should have application.

Methods of Measuring HCN Potential of Sorghums

Although many procedures have been used in the past to determine the HCN potential of sorghum, the sodium picrate procedure, first used by Boyd et al. (1) on sorghums, appears to be the most reliable. This procedure was modified by Hogg and Ahlgren (8) to include quantification using a photoelectric colorimeter.

The procedure is based on the formation of sodium picrate by reacting picric acid and Na_2CO_3. With CN^- in the form of NaCN it reacts with sodium picrate to form sodium isopurpurate (dark red). The formation of the red color (increasing intensity with increasing CN^- levels) is the basis for quantification using a colorimeter.

Quantification of the HCN Liberated from Sorghum:

In years past forage from both management and variety-screening studies have generally been subjected to qualitative techniques when comparing HCN levels. The procedure was to visually compare the unknown to a set of KCN standards. These results were frequently expressed as ppm; however, considerable subjectivity occurred when the unknowns were visually compared to the standard. Although this permits relative ranking within a study, these data do not permit comparisons of HCN levels in forage among laboratories both within and among regions. More effort on quantitatively determining the HCN potential of forages would assist in establishing HCN levels expected in forage grown in different climatic regions. After time, such data would also help in arriving at a critical level of HCN above which adverse animal responses

might be associated.

Methods:

A modification of the sodium picrate method describing field sampling, sample preservation and preparation, and complete quantification of HCN liberated from plant tissue has been recently published (3). The procedure provides both good accuracy and high precision.

A potentiometer procedure involving the use of cyanide electrode in measuring the quantity of HCN liberated from plant tissues may be useful when screening large numbers of samples (7). Once the HCN is liberated, the cyanide electrode and reference electrode are placed into the solution and an mv reading is taken from the dial of a pH meter. This procedure gave similar relative results when compared with the sodium picrate procedure; however, absolute values from the potentiometric method were approximately 40% higher. The major advantage of the latter method appears to be a time-saving factor since the distillation and color development steps required in the sodium picrate procedure are omitted. However, the data would need to be adjusted back to absolute values before it would assist in determining critical levels in the plant.

Forage Sampling

The purpose of the study generally dictates the selection of field samples. However, it is important to be aware of the following kinds of variation:

Plant Parts:

(1) Leaves are higher in HCN potential than are stems.

(2) Leaf tips are higher in HCN than are leaf bases.

(3) Immature forage is higher in HCN potential than is mature forage.

Sampling Time:

Prussic acid potential of plants exhibits diurnal variation. Levels have been shown to generally increase from 8:00 a.m. to 10:00 a.m. In some studies HCN levels continued to increase until 2:00 p.m. before leveling off or actually showing a decline.

Sample Preservation:

Because of the labile nature of liberated CN^-, it is extremely important to insure that samples are properly preserved until chemical analyses are completed. If absolute levels are of major concern, no loss of HCN can occur prior to or during the analyses. If relative concentrations are of major concern, similar losses (if any) must occur among all samples.

In comparing methods of preservation Gilchrest (6) found that samples chilled in ice gave higher HCN readings than did fresh forage. Also, forage frozen in dry ice gave lower HCN readings, while over-dried forage resulted in quite variable readings. He concluded that fresh forage placed in a polyethylene bag, sealed, and stored in the dark at 32 C gave results similar to the fresh forage. Burns et al. (3) showed no significant loss of HCN for 6 hr when samples were preserved in the same manner, but at 26 C.

Implications of Above Sources of Variation:

When evaluating the HCN potential of forages, it is critical to standardize all procedures. This includes selection of plant material in the field, time of sampling, preservation of sample, and the analytical procedure. Any variation in these will cause confounding of treatments (management or varieties) such that differences obtained may involve considerably more than only treatment effects.

Protective Measures to Avoid Possible HCN Poisoning

(1) Plant varieties recommended by the agricultural experiment station. These are generally high yielding and low in potential HCN release.

(2) It is generally recommended not to graze sorghum grasses until plants reach 18-24 inches in height. This permits dilution of HCN normally found in young tissue.

(3) Under conditions where nitrogen has been applied at seeding and the weather has turned dry resulting in stunted plants, high prussic acid release should be suspected.

(4) Frozen forage should not be grazed, but can be utilized about 24-48 hours after thawing. Animals should not be permitted to graze lush growth normally initiated after a killing frost. These sprouts are extremely high in prussic acid release.

(5) Animals should be given a full-feed of hay prior to turning onto sorghum grasses. If animals are hungry and eat large quantities of forage in a short period of time, normally safe material may become lethal.

(6) Sorghum pastures should be grazed down to desired uniform height and cattle removed. This will prevent selective consumption of lush regrowth.

(7) If prussic acid poisoning is suspected or conditions are such that high HCN release is expected when cattle are turned into sorghum pasture, the local veterinarian should be contacted immediately.

Since 1930 much has been learned and done to prevent losses from HCN poisoning. New varieties with low HCN potential have been developed as well as information gathered regarding sorghum management and utilization. At

the present time, sorghum hybrids are being utilized on the farm while evaluation for HCN content, yield, and chemical composition is continuing at the experiment stations. Today sorghum grasses are grown and successfully grazed over large areas of the country; however, HCN poisoning is still a factor that must not be ignored.

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Nitrate Nitrogen Accumulation
in Summer Forages[1/]
Billy B. Tucker
Oklahoma State University

Nitrogen is essential for the growth of plants. It is needed in relatively large amounts as compared to other essential nutrients. Nitrogen is a constituent of protein and nucleoproteins. Proteins are so vital to plant functions and are necessary for reproduction, growth, and respiration. Whenever nitrogen is deficient in the soil, these plant functions slow down or stop completely.

Nitrogen is a mobile nutrient both in the soil and plant. It constantly undergoes chemical change. As new cells form, much of the nitrogen may move from older cells to the newer ones. As maturity approaches, nitrogen moves from the vegetative parts into the seeds. The form that the nitrogen is in upon movement varies between plant species.

The need for and function of protein in animal health is well known. Quite often quality of grain and forage is rated on the protein content.

Nitrogen fertilization is essential for growth and protein formation. It is usually easy to predict protein contents of crops by utilizing yield levels and soil nitrogen applications.

However, not all nitrogen in plants occurs in the protein form. Nitrate-nitrogen is widely recognized as a normal constituent of plants. In most plant species, the amount of nitrate-nitrogen is small unless some adverse nutritional status or environmental condition exists. Fertile soils, high in nitrogen, regardless of the source, whether it be fertilizer nitrogen, nitrogen fixed by legumes, or nitrogen added by manure, can accentuate nitrate-nitrogen accumulation in plants whenever other elements are deficient or adverse environmental conditions prevail.

It is not a choice of whether to keep plants well supplied with nitrogen. Nitrogen fertilization is a must to not only grow sufficient quantities of food and adequate protein for good health but also for economic crop production. It does behoove us, however, to be cognizant of increased possibilities of nitrate-nitrogen accumulations and to understand those conditions that may lead to possible toxic levels of nitrates in forages. Only by understanding conditions which may cause toxic concentrations can remedial measures be instituted.

1/ The author is indebted to Dr. Larry Murphy, Associate Professor, Soil Fertility, Kansas State University, whose Ph.D. Dissertation, University of Missouri, June 1965, was heavily relied upon in preparing this paper.

Effect of Nitrate-Nitrogen on Animal Physiology:

The problem of high nitrates in forages is now new. Reports of nitrate

poisoning of cattle came from Kansas in 1888. Extremely heavy losses of livestock caused by nitrate poisoning occurred in Colorado and Wyoming in the 1930's. Wyoming workers determined that conversion of hemoglobin to methemoglobin was associated with the poisoning. These workers drenched animals with water extracts of the hays or solutions of pure KNO_3 produced symptoms identical to those observed with feeding the hay. In all cases, the affected animals' hemoglobin was largely converted to methemoglobin. Since then, numerous research trials in the United States and Canada have substantiated these conclusions.

During the drought of the early 1950's heavy livestock losses were reported in the Midwest. Corn that had been heavily fertilized for high yields was cut for ensilage when hit by high temperatures and low soil moisture. As a result of high fertilization combined with extremely low levels of soil moisture, corn plants had taken up and stored large amounts of nitrate-nitrogen. Other drought-striken forages such as sudangrass, sorghum, and some other grasses were also responsible for the death of livestock.

In Oklahoma and Texas, cattle deaths and abortions while grazing small grains, sorghums, and bermudagrass have been attributed to toxic levels of nitrates by veternarians.

Nitrates in themselves are not toxic to livestock and all forages contain some nitrates. When nitrates are eaten by ruminants, they are broken down to ammonia and then converted by bacteria into protein.

One of the intermediate products is nitrite. Nitrite converts the hemoglobin of the blood into methemoglobin which cannot then carry oxygen from the lungs to other tissues. It actually oxidizes the iron of the hemoglobin from normal ferrous (Fe^{++}) state to ferric (Fe^{+++}) state. This lack of oxygen causes a grayish to brownish discoloration of the skin surrounding the eyes, nose, mouth, and vulva. Later, breathing becomes labored, pulse rate increases, gait becomes staggered, and frequency of urination increases. These symptoms may be followed by a coma, convulsions, and death. A positive diagnosis is chocolate-brown blood, but the diagnosis must be performed soon after death occurs. Methemoglobin in blood is not always detrimental. Whenever poisoning occurs from hydrocyamic acid from sorghum, injection of methemoglobin is injected to help alleviate the problem.

Nitrate poisoning can occur in sheep and swine as well as cattle, but problems with swine are extremely rare. Ruminant animals are most susceptible to nitrate poisoning whenever methemoglobin is the problem because it is in the rumen where bacteria convert nitrates to nitrites and the nitrites are absorbed into the blood stream. In monogastric animals nitrites are toxic if ingested directly but insufficient bacteria are present to convert nitrates to nitrites at a rapid rate. However, it has been reported that high concentrations of nitrates can cause other nutritional disorders in non-ruminant animals such as vitamin deficiencies.

In addition to losses from acute nitrate toxicity caused by production of methemoglobin production chronic or sublethal toxicities have been

reported. Impaired vitamin A, vitamin E, and iodine nutrition have been postulated as sublethal effects. The thyroid gland produces a harmone, thyroxine, that governs the general rate of metabolism throughout the body. A reduced production of thyroxine slows the rate of enzyme-catalyzed reactions, retards growth of muscle and bone, and lowers production of milk and wool. Iodine is a constituent of the thyroxine molecule and the presence of inorganic anions such as nitrates and nitrites may decrease the concentration of iodine in the thyroid gland, indirectly lowering the rate of thyroxine synthesis.

Many vitamin A deficiencies occurring in feedlot cattle that depended on carotene in forage to meet their needs for vitamin A has been blamed on the nitrate contained in the forages being fed. Carotene, a plant pigment that possesses no vitamin A activity, is normally converted into vitamin A in the intestinal walls of animals. On the basis of the previous speculation that dietary nitrate lowered production of thyroxine by the thyroid and that an active thyroid increases the conversion of carotene to vitamin A, it has been speculated that the nitrate could act through the thyroid to produce vitamin A deficiency in cattle. It would be expected that if the above were true for feedlot animals the problem would be accentuated where animals were grazing forage and the forage constituted the entire diet. Some studies have also shown that gaseous oxides of nitrogen produced during fermentation of silage, while nontoxic, in themselves destroyed carotene.

Vitamin E deficiencies have been reported in rats fed rations high in nitrate-nitrogen, but this effect has not been noted in farm animals.

The vitamin A, vitamin E, and iodine deficiencies suggested as being caused by high levels of nitrate-nitrogen has not been definitely confirmed by clear-cut experimentation; but it appears there may well be an interaction of nitrate-thyroid-vitamin A.

There is less evidence to indicate sublethal effects of nitrate on reproduction than there is on growth. There is no doubt that abortions in cattle have been caused by excessive nitrate; but experimentally, amounts must be fed far above the levels described in the popular literature as dangerous to pregnant animals. Experimentally, the level of nitrate that will cause abortion in the ruminant cannot be distinguished from the level that will cause death. In the case of dairy cows, it appears that nitrate is unlikely to lower milk production unless it is fed at a level that keeps the cows on the threshold of collapse, or at a level that lowers feed consumption.

Research conducted at the South Dakota Agricultural Experiment Station and agreed upon at a symposium sponsored by the National Nutritional Laboratory[2] rates toxicity of nitrates in forage in Table 1.

[2]Department of Agronomy Proceedings of a Symposium on Nitrate Accumulation and Toxicity, P. 54A, Agronomy Mimeo., No. 46. Cornell University, Ithaca, New York, (1963).

Table 1. Toxicity Levels of Nitrate-Nitrogen

Nitrate-N Content Percentage	Toxicity
0 - 0.15	Safe under all conditions
0.15 - 0.3	Limit to 1/2 total dry matter in ration
0.3 - 0.45	Limit to 1/4 of total dry matter
Over 0.45	Potentially toxic (Do not feed)

Plant Factors Influencing Nitrate Accumulation:

Taxonomic units of plants are known to differ in tendancy to accumulate nitrate. Plant species have been grouped as nitrate-nitrogen accumulators and non-accumulators. These groupings are valid for generalization but it must be remembered that even those normally low in nitrates may under special conditions accumulate it to dangerous levels. Furthermore, plants classified as accumulators only possess the tendency and will be low whenever the rate of assimilation keeps pace with the rate of uptake.

Plants are rated in a general fashion as to their tendency to accumulate nitrates in Tables II and III. It is noted that many weed species do tend to accumulate nitrates, perennial grasses tend to be low, summer annuals in general are nitrate accumulators. Sorghums and corn tend to accumulate nitrates more than most other crops.

Studies on bermudagrass show that it has an extremely low tendency to accumulate nitrates. (Figure 1)

Varietal differences in nitrate accumulation have been reported within species of oats, corn, perennial ryegrass, timothy, and sorghum-sudan hybrids. An example of varietal and hybrid differences is given in Table IV, reported from a study conducted at the Oklahoma Agricultural Experiment Station.

TABLE II. A generalized rating of some common forage plants and weeds as to their tendancy to accumulate nitrates.[1]

CAPABLE OF ACCUMULATING NITRATES		
High		Low
Sorghums	Goosegrass	Bermudagrass
Johnsongrass	Soybean	Orchardgrass
Sudangrass	Sweetclover	Timothy
Wheat	Pigweeds	Fescue
Oats	Prickly Sow Thistle	Grama grasses
Rye	Canadian Thistle	Bluestems
Barley	Russian Thistle	Brome grasses
Corn	Milk Thistle	Buffalograss
Sugar Beet	Lambsquarters	Weeping Lovegrass
Turnip	Morningglory	
Rape	Sunflower	
Rescuegrass	Carolina Horsenettle	
Crabgrass	Puncturevine	

[1]Based upon information from California Experiment Station and Extension Circular 506 and other data.

TABLE III. ACCUMULATION OF NITRATE–NITROGEN BY FORAGE SPECIES. (MISSOURI, 1965)

Species	Accumulation of Nutrients
Sudangrass	Very high
Sorghum - Sudan Hybrids	"
Orchardgrass	Significant amounts
Tall Fescue	"
Bromegrass	"
Timothy	"
Bluegrass	Low amounts
Wheat	"
Ladino	"
Alfalfa	"

Figure 1

Influence of Rate of Nitrogen on Nitrate-Nitrogen

Content of Irrigated Bermudagrass

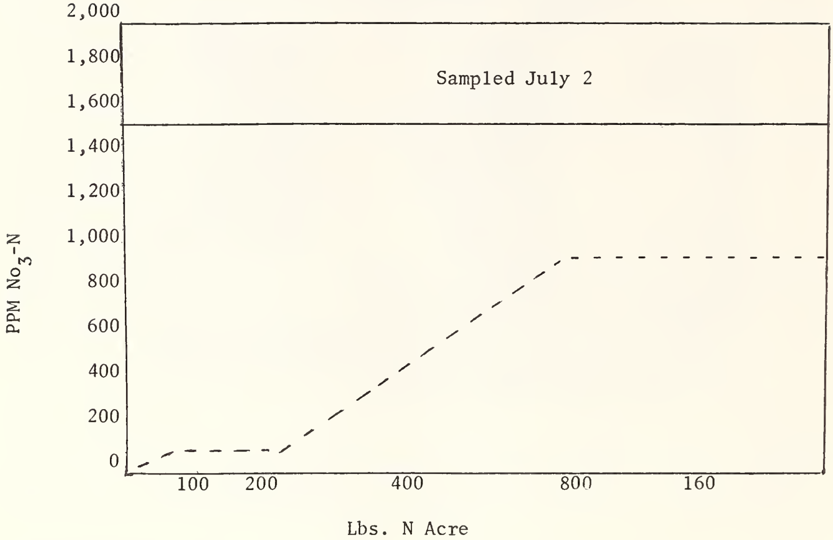


TABLE IV. Nitrate content of Sudangrass leaf samples fertilized with 160 pounds of Nitrogen per acre for each clipping. (Oklahoma, 1966)

Variety or Hybred	Nitrate-Nitrogen PPM Clipping 1	2	3
Piper	341	196	97
Sweet	999	218	323
Sweet Sioux	781	300	279
Haygrazer	1426	585	318
Dekalb SX-11	948	410	499
Trudan I	1056	260	179
Horizon SP-110	601	353	240

Nitrate is not uniformly distributed throughout the plant. Numerous studies have shown that stems and petioles are higher in nitrates than leaves and floral parts. The lower portions of stems tend to be higher in nitrate content than the upper portions. Older leaves are lower in nitrates than the younger leaves because nitrates tend to be translocated to the terminal growth and to seeds.

Plant species differ in their concentration of nitrates at various stages of growth. Many plants are high in nitrates early and then decline with age (Figure 2). This seems to be true with nitrate accumulators. However, in several species the nitrate content first rises and then, after reaching a peak about the pre-bloom stage, declines as the plant matures. Other species such as small grains are low in nitrates early but tend to accumulate larger amounts just prior to head formation, and then they decline as the plant matures (Figure 3).

Environmental Factors Affecting Nitrate Accumulation in Forages:

The presence of nitrates in certain plants is normal, and the nitrate content has been shown to be positively associated with ultimate yield. Tissue testing for nitrates has been used as a guide for optimum nitrogen fertilization.

As has been previously stated, nitrates accumulate whenever the rate of uptake exceeds the rate of assimilation. Any condition affecting either the uptake or assimilation will affect nitrate accumulation.

The most obvious way to increase rates of nitrate uptake is by increasing the quantity present in soil solution. Many experiments across the country have yielded data to show that increasing rates of nitrogen fertilization do in effect increase nitrate accumulation as well as protein and other nitrogen fractions. Most studies do show that unless there is some adverse growing situation nitrate-nitrogen accumulates only to sublethal levels even with extremely heavy nitrogen fertilization (Tables V and VI).

TABLE V. The Effect of Nitrogen Rates on the Nitrate-Nitrogen Contents of 3 Forage Species. (Missouri, 1965)

Rate of N	Nitrate in Mgms.		
	Wheat	Fescue	Bromegrass
0	0.00	0.01	0.01
200	0.69	0.93	1.52
400	1.46	1.63	1.47
800	1.66	1.72	2.03

TABLE VI. The Effect of Nitrogen Rates on Nitrate-Nitrogen of Sudangrass and Sorghum-Sudan Hybrids. (Oklahoma, 1966)

Rate of N (Each clipping)	Nitrate - Nitrogen in PPM Variety of Hybrid			
	Piper	Haygrazer	Horizon SP-110	Trudan I
0	71	103	56	83
20	65	105	62	146
40	107	147	137	175
80	152	264	249	392
160	211	776	398	498

Figure 2

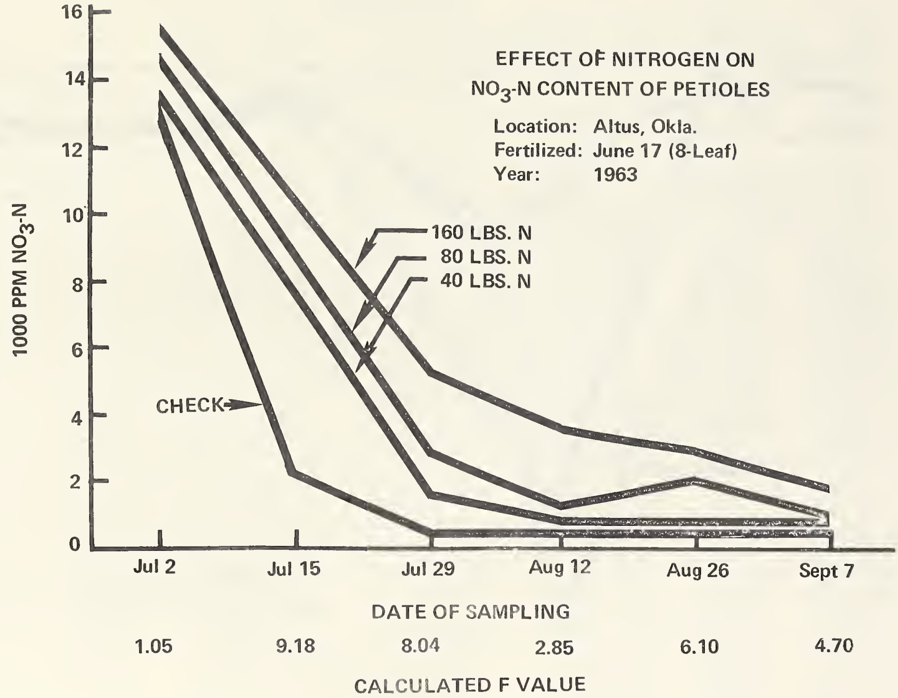
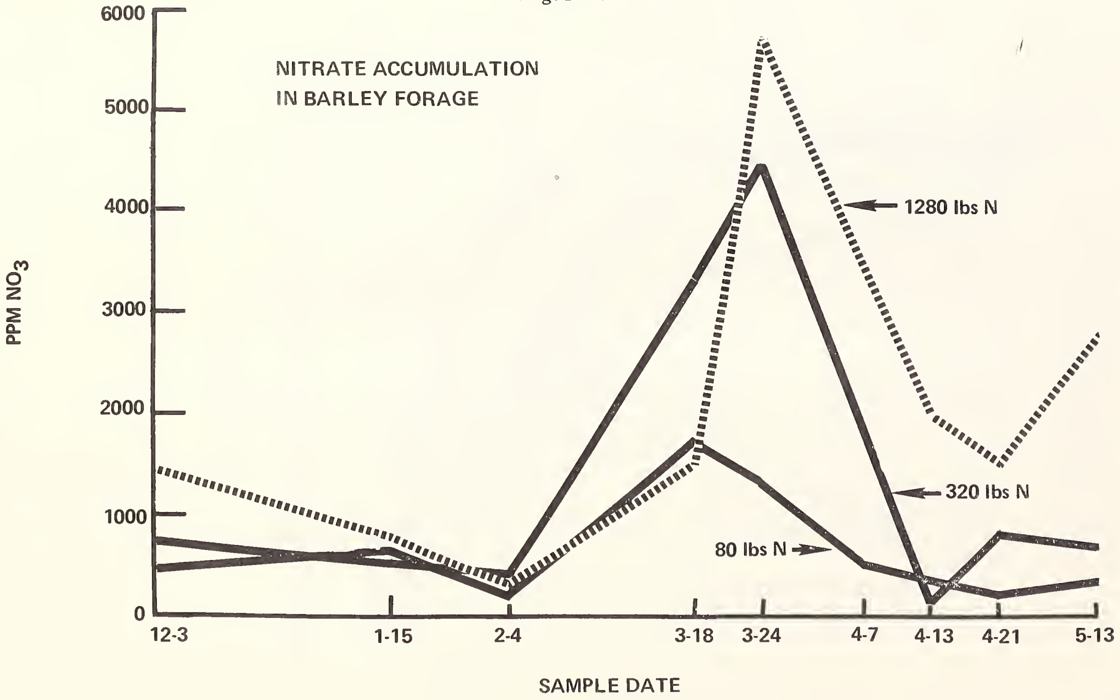

EFFECT OF NITROGEN ON
NO_3-N CONTENT OF PETIOLES
Location: Altus, Okla.
Fertilized: June 17 (8-Leaf)
Year: 1963
160 LBS. N
80 LBS. N
40 LBS. N
CHECK
1000 PPM NO_3-N
16
14
12
10
8
6
4
2
0
Jul 2
Jul 15
Jul 29
Aug 12
Aug 26
Sept 7
DATE OF SAMPLING
1.05
9.18
8.04
2.85
6.10
4.70
CALCULATED F VALUE

Figure 3


NITRATE ACCUMULATION
IN BARLEY FORAGE
PPM NO_3
6000
5000
4000
3000
2000
1000
0
12-3
1-15
2-4
3-18
3-24
4-7
4-13
4-21
5-13
SAMPLE DATE
1280 lbs N
320 lbs N
80 lbs N

Deficiencies of nutrients other than nitrogen, particularly those involved in protein synthesis, often result in unusually high accumulations of nitrate due to limitations on assimilatory processes. As an example, high nitrate is often associated with deficiencies of phosphorus (Table VII and Figure 4).

There is also published results showing that sulfur and manganese deficiencies promote nitrate accumulations. Unpublished results from research in progress on iron deficient small grains in Oklahoma show that iron deficiency can also cause nitrates to accumulate.

Studies on the influence of the intensity, duration, and quality of light has shown that a reduction in light intensity has been associated with an increase in nitrate content of forages (Table VIII). Therefore, shading by high plant populations, tall growth, and cloudy days would be expected to increase nitrates in the forage. These findings have been confirmed in field studies but with a lesser magnitude of differences.

Nitrates have been observed to increase during periods of hot, dry weather which lead to the conclusion that perhaps accumulation increased as temperatures increased. The reverse seems to be true (Table VIII). But any experiments varying temperature are usually confounded with growth rates and increased rates of soil nitrification. However, it seems safe to predict that nitrate accumulation during hot, dry weather is more a function of moisture stress than high temperatures.

Any condition interferring with normal plant growth can cause nitrate accumulation. Moisture stress will increase nitrates in plants unless the soil is too dry for nitrate absorption. Whenever surface moisture is depleted but sufficient subsoil moisture is present for sustained growth, nitrates are not likely to accumulate. Such weather conditions as frost, hail, and freezes can cause nitrates to accumulate. The faster a situation stops normal growth, the more likely nitrates will accumulate.

Some reports of nitrate accumulation due to herbicide sprayings have been received. Spraying with 2,4-D does often result in temporary high nitrate levels in forages. Some herbicides tend to disrupt the normal enzyme systems of plants. Enzymes are essential for the reduction of nitrates and their subsequent conversion to protein. Therefore, cattle may need to be temporarily taken off pastures, if the species is a nitrate accumulator, following herbicidal application. It must be pointed out, however, that judicious spraying of pastures and forages to control weeds often actually reduces the hazard of nitrate poisoning because weed species which are normally high in nitrates are eliminated.

Some insecticides have increased nitrates, but the amounts used are not usually sufficient to be of practical concern; and here again, the chemicals usually have a lesser influence on nitrate accumulation than the malfunctions caused by the pest they are intending to destroy.

TABLE VII. Influence of Rates of Phosphorus on Nitrate-Nitrogen Accumulation in Wheat Forage at Different Sampling Dates. (Oklahoma, 1971)

Rate, lbs/A			No_3·N Concentration, PPM			
N -	P_2O_5 -	K_2O	Feb. 2	Mar. 6	Mar. 15	Mar. 21
0	0	0	300	200	200	400
80	0	40	300	800	1300	900
80	30	40	500	200	300	600
80	60	40	500	200	200	400
80	90	40	300	200	200	400

TABLE VIII. Effects of Light Intensity and Temperature on the Nitrate Content of Dekalb SX-11 Sorghum, Sudan Hybrid. (Oklahoma, 1966)

Light Foot-candles	Nitrate - Nitrogen PPM Temperature in Degrees F.		
	50	70	90
3000	970	208	383
1500	1508	1066	1594

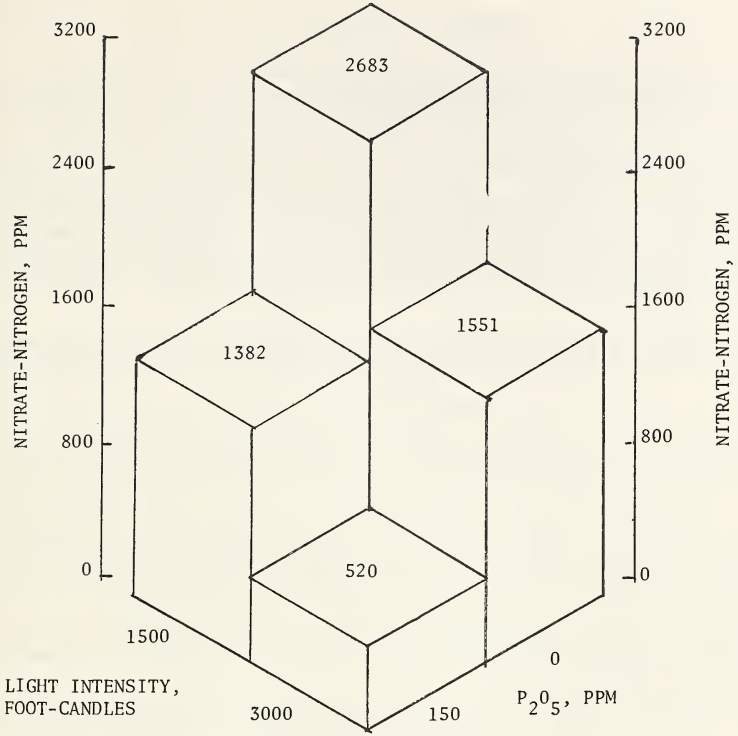


Figure 4. Effects of Light Intensity and Soil Phosphorus Level on the Nitrate Content of Dekalb SX-11 (Oklahoma, 1966).

SUMMARY

Nitrates are a normal constituent of plants. Amounts vary considerably among species and within species due to nutritional and other environmental factors. In spite of considerable research and experience, it is still difficult to predict amounts of accumulation under definite situations, but certain principles are evolving.

Animal losses due to high nitrates in forages occur annually, but losses are still rather small considering the number of livestock being produced. Losses can be reduced even further utilizing known information. More forage testing for nitrate contents of forage produced under adverse conditions seems warranted.

Further research is needed to elucidate the factors and formulate principles involved, but no sweeping changes in agronomic practices appear to be needed.

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Summer Annual Legumes

Ian Forbes, Jr.
USDA, ARS, PSRD, Tifton, Georgia

Our program chairman, Cliff Mondart, has given me wide latitude in the material I would cover in this talk. Yesterday I participated in the Physiology and Ecology Work Group program which comprised a series of six papers on grass-legume mixtures. We had one of the most stimulating work conferences from the standpoint of forage legumes that I, as a forage legume breeder, had ever attended. This was due partly to the orientation of the topics toward the successful use of forage legumes, and partly to the relaxed and informal discussions of each topic by the entire group.

Although my topic in the Physiology and Ecology session was "Summer legumes in perennial grass sods", Program Chairman Carl Hoveland had also given me wide latitude in what I would cover. Therefore, as part of my talk I synthesized and presented a group of postulates and facts regarding the desirable attributes of forage legumes as a whole and hazards to their expanded, efficient use. I propose to expose the present audience to the same "legume philosophy" to stimulate them to reexamine their "forage philosophy" and to invite constructive criticism of the "legume philosophy" presented.

Forage legumes in general have many desirable attributes: 1) the cheapest source of plant protein for ruminants; 2) the cheapest source of N for associated grasses; 3) less tendency than most mineral sources of N to lower soil pH; 4) higher forage quality than sub-tropical (and many temperate) grasses; 5) tendency to increase total animal intake of grass-legume mixtures; 6) tendency to increase animal daily gains; 7) tendency to increase milk-flow; 8) tendency to increase conception rate; 9) "minor" forage legumes are a germplasm reservoir for future major forage crops and vegetable protein and oil crops; and 10) former "minor" forage legumes in the U.S.A. include soybeans, peanuts, and southern peas (cowpeas).

Forage legumes in general face several hazards to their expanded, efficient use: 1) most mineral nitrogen fertilizers which lower soil pH, sooner or later resulting in nutrient deficiencies (Ca, Mg, S, P, & Mo) and Mn and Al toxicity; 2) soils too low in native nutrients or naturally too low in pH; 3) grasses that compete too strongly for available major, secondary, and micronutrients, and water, space, and light; 4) nematodes; 5) fungi; 6) viruses; 7) insects; 8) poor establishment and management techniques; 9) absence of any, or the best, *Rhizobium* strain for efficient nodules; and finally 10) the "grass + N" syndrome that involves agronomists (and supporting scientists, administrators, research budgets, and agri-business promoters.

Summer annual legumes that are used (or show promise for use) in the Southeast in grass-legume mixtures include: *Aeschynomene americana*, *Alysicarpus vaginatus*, *Arachis monticola*, *Indigofera hirsuta*, *Lespedeza stipulacea*, *Lespedeza striata*, and *Stylosanthes humilis*.

Summer annual legumes that are used (or show promise for use) in the Southeast in mono-culture include: Aeschynomene americana, Alysicarpus vaginatus, Desmodium tortuosum, Dolichos lab lab, Glycine max, Indigofera hirsuta, Stizolobium deeringianum, and Vigna sinensis.

Of the legume species mentioned only the annual lespedezas, soybeans, velvet beans, and cowpeas are known to be widely adapted in the Southeast. Most of the remaining species are restricted in use to Florida or else are so newly introduced that their area of possible use is ill-defined. A minimum amount of, or no, effort has been made to improve through breeding the latter legume species.

Stylosanthes humilis, although promising in Florida, will not reseed as far north as Tifton, Georgia. This has been the experience with many sub-tropical legumes received from the Australian breeding programs. This might be rectified through breeding. We are presently screening introductions with this in mind.

The most productive summer annual legume recently tested at Tifton is Dolichos lab lab. It is large-seeded, and the robust accessions fail to set seeds before frost. We have located an accession that flowers in early summer and are in the process of breeding a vigorous biotype that will produce seeds at Tifton. Seeds of the robust Australian variety 'Rongai' are available commercially.*

*Several research workers requested that I include in my abstract the address of the Australian seed company from whom I have obtained seeds of the Australian sub-tropical legumes: Andersons Seeds Limited, 68 Boundary Street, P. O. Box 983M, Brisbane, Australia.

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Pre-Conference Executive Committee Meeting
Tuesday, July 6, 1971

The Executive Committee meeting of SPFCIC was called to order at 4:50 P.M. by Chairman D. H. Timothy. Present were C. Mondart, D. Timothy, R. Buckner, and R. Leffel, (SPFCIC); J. Lusk (S-45); W. Sell (for J. Johnson) and H. White and L. Rommann (SFEWG); J. Powell (SFBG); A. Spooner (SFPEWG); and P. Gibson (representing 1972 Host Institution).

Chairman Timothy announced that the Nomination Committee is P. Gibson, D. Chamblee, and M. Riewe (Chairman); and that the Resolutions Committee is H. Fribourg, L. Rommann, and L. Taylor (Chairman). Also, he announced that the 1972 meeting site was confirmed by Associate Director Halpin at Clemson and that the meeting at Clemson in 1972 will be during the week of May 8-12 or 15-19. The Forage Evaluation Committee report will be given by J. Moore. It was noted that J. Velez Fortuno is next year's Chairman for SPFCIC, and that Velez Fortuno informed us last year that he may be on sabbatic leave, August 1971 to August 1972. Timothy will contact Velez Fortuno and advise us of any required realignment of duties. Leffel reported a Treasurer's balance of $165.71.

A motion to accept Clemson University's invitation to SPFCIC, offering Clemson as the site for our 1972 meeting, passed. Gibson inquired as to the Conference's preference for rooms — dormitories, Clemson House, or motels. Several in attendance and familiar with Clemson's facilties suggested a facility with rooms, meeting rooms, and dining room provisions, such as offered by Clemson House in the past. Gibson announced a remodeling and change of management and function of Clemson House. Newly elected officers for the Work Groups were announced: H. Lippke (S-45), P. Gibson (SFBG), A. Spooner (SFPEWG), and L. Allen (SFEWG).

Chairman Timothy announced the next meeting of the Executive Committee immediately after the Banquet tomorrow evening, July 7, and requested that all members give serious consideration to next year's Program. The meeting was adjourned at 5:15 P.M.

SPFCIC General Business Meeting
Wednesday, July 7, 1971

The general business meeting of SPFCIC was called to order at 4:52 P.M. by Chairman D. Timothy. The report of the Forage Evaluation Committee was given by J. Moore, and is appended herein. The Motion to accept this report carried. The report of the Resolutions Committee, appended herein, is to be given during the Banquet tonight.

The following Motion (amended) was introduced by H. Fribourg, seconded by I. Forbes, and passed unanimously:

"WHEREAS, the *Rhizobium* genus is capable of manufacturing nitrogen in a form usable by forage and other legume species; and

WHEREAS, research on the genus *Rhizobium* is a highly specialized discipline; and

WHEREAS, the Federal Government in the past has provided outstanding leadership in pioneering research with *Rhizobium* strains which differ in their capability to associate symbiotically with different legumes; and

WHEREAS, the Federal Government in the past has served forage research workers throughout the Nation by providing effective strains of *Rhizobium* for the many legume species; and

WHEREAS, this pioneering research and these services have been summarily terminated;

THEREFORE, BE IT RESOLVED:

That, this, the membership assembled of the 28th Annual Southern Pasture and Forage Crop Improvement Conference, unanimously calls upon the Secretary of Agriculture,

To restore and to support an accelerated and expanded program in *Rhizobium* research and services, the same being considered by this Conference to be of critical importance for the well-being of the Nation and of the World in providing the basic knowledge and the organisms necessary for supplying an exploding population with essential vegetable oils and proteins.

This the seventh day of July nineteen hundred and seventy-one."

Chairman Timothy announced that an invitation from Clemson University offering to host SPFCIC in 1972, was accepted by the Executive Committee. The Conference will meet at Clemson probably during the week of May 8-12 or 15-19, a definite date to be announced by the Host Institution.

M. Riewe presented the Nomination Committee report, nominating J. McCroskey as Chairman Elect-Elect. A Motion to close the nominations and to elect McCroskey by acclamation carried unanimously.

The meeting was adjourned at 5:13 P.M.

Report of Forage Evaluation Committee — SPFCIC

The S-45 Regional Project Technical Committee acting as the Forage Evaluation Committee of SPFCIC presents the following report in order to bring before the Conference certain recent developments and considerations which are pertinent to the problems involved in routine laboratory evaluation of forage quality.

1. The two stage *in vitro* rumen fermentation technique continues to be the method of choice for screening large numbers of samples. A recent paper (J. Anim. Sci., 32:1030, 1971) compared several *in vitro* techniques. In this study, the determination of either the digested dry matter or digested neutral detergent fiber gave good predictions of the *in vivo* digestibility of dry matter and energy, but neither technique was a good predictor of voluntary intake.

2. Caution should be exercised in the interpretation of *in vitro* data when several species or genera of forages are being compared to each other. The *in vitro* digestion of some forages may be lower than that of others even when the *in vivo* digestibilities are the same. This discrepancy may occur because of different rates of fermentation. At this time no definite answer to the problem is possible, but it will be further evaluated as part of the S-45 project.

3. The importance of careful experimental design in conducting large scale *in vitro* studies must be emphasized. Frequently it will be impossible to run simultaneously all samples in a given experiment. This means several different *in vitro* runs conducted on different days will be necessary. In such cases the variation between *in vitro* runs conducted on different days makes it impossible to directly compare a forage analyzed in one run with another forage analyzed in a different run. The recommended approach is to use a statistical design, decided on prior to the experiment, which permits removing the variation between runs in the statistical analysis.

4. The Committee felt that SPFCIC would be interested in a basic research approach being taken by Dr. Don Jacobson of Kentucky and his associates. A technique has been developed for measuring the absorption of nutrients by ruminants. Amino acid absorption has been studied in animals fed alfalfa hays of different qualities. Feeding the high quality hay resulted in several times more amino acid absorption than did the lower quality hay and the difference in absorption between the hays was much greater than would have been expected from the difference in crude protein content. Such information emphasizes not only the importance of high quality forage

but also the value of improved and new techniques by which forage quality may be better understood and evaluated.

Presented by: John E. Moore, University of Florida

Report of Resolutions Committee

It is a signal honor and pleasure to present to you this report of the Resolutions Committee:

"WHEREAS, the membership of the 28th Annual Southern Pasture and Forage Crop Improvement Conference, in body assembled, has enjoyed incalculable benefits from its participation at the Conference, and

WHEREAS, such benefits could not have been without the fine, warm hospitality and concerted efforts of the staff and administration of Oklahoma State University and associations, groups and individuals;

BE IT RESOLVED:

That this 28th Conference expresses the deepfelt appreciation of its membership, to the staff and administration of Oklahoma State University for the warmth and gentility of the welcome extended to it and the use of the superior facilities provided during the meeting in Stillwater and the field trip to Fort Reno;

That Oklahoma State University and its personnel are to be commended for their awareness of the agricultural problems of today and of tomorrow, and for their leadership and vision in tackling and solving the problems that the improvement, the management, and the utilization of forage crops will face on their way to the 21st Century for the benefit of Humankind;

That special recognition is extended to the Oklahoma Crop Improvement Association, the Oklahoma Seedsmen Association, the Oklahoma Plant Food Education Society, Stillwell Food Inc., and the Oklahoma Peanut Commission, for their support of the Local Arrangements Committee; that thanks and appreciation be extended to Ralph S. Matlock, Charles M. Taliaferro, Loren M. Rommann, Jack McCroskey, Billy B. Tucker, Lavoy I. Croy, W. E. McMurphy, Jeff Powell, Robert E. Ahring, J. B. Lemaster, Harold Myers, and Bill Webb.

That special recognition is due and extended to Chairman David H. Timothy, to Past Chairman and Program Chairman Cliff L. Mondart, Jr., and to our esteemed and valued Permanent Secretary, Robert C. Leffel.

THEREFORE,

We move that this resolution be adopted by unanimous acclamation and inscribed in the Minutes; and further, that a copy of this resolution be sent to:

Robert B. Kamm, President, Oklahoma State University
James A. Whatley, Dean of Agriculture
William F. Taggart, Director of Extension
James C. Hillier, Head, Dept. of Animal Sciences & Industry
Ralph S. Matlock, Head, Department of Agronomy
Ed Granstaff, Oklahoma Crop Impr. Assoc., Secretary-Manager
Kenneth Otwell, Oklahoma Plant Food Education Soc., President
Quinton Ogden, Oklahoma Seedsmen Association, President

Henry A. Fribourg
Loren M. Rommann
Lincoln H. Taylor"

Post-Conference Executive Committee Meeting
Wednesday, July 7, 1971

The Executive Committee meeting was called to order by Chairman D. Timothy at 9:00 P.M. Present were J. Lusk and M. Montgomery (S-45); R. Smith and P. Gibson (SFBG); A. Spooner (SFPEWG); H. White, W. Sell (for J. Johnson), L. Rommann, and L. Allen (SFEWG); and M. Riewe, C. Mondart, D. Timothy, R. Buckner, J. McCroskey, and R. Leffel (SPFCIC). Current officers of Work Groups and Conference are as follows:

	S-45	SFBG	SFPEWG	SFEWG	SPFCIC
A. Adv.	C. Little	O. Garrison		F. Ellmore	
P.P.Chr.					C. Mondart
P. Chr.	J. Lusk	C. Taliaferro	C. Hoveland	H. White	D. Timothy[1]
Chr.	M. Montgomery	R. Smith	G. Spain[1]	J. Johnson	J. Velez Fortuno
Chr. E.			R. Brown	L. Rommann[1]	R. Buckner
Chr.E.E.					J. McCroskey
Secretary	H. Lippke[1]	P. Gibson	A. Spooner	L. Allen	R. Leffel
Directors	J. Burns				
	J. Arroyo-Aguilo				

[1] Program Chairman, 1972.

Members of SPFCIC Executive Committee are underlined in above table. Chairmen (or their designated representative) and Past Chairmen of Interest Groups (1 vote per Interest Group) and officers of SPFCIC constitute the Executive Committee of SPFCIC.

The Program for SPFCIC, 1972, was discussed: SFPEWG suggested a program on tall fescue, such as held at Athens, Georgia, in 1970 on bermudagrass by SFPEWG. Duplication in programs by SPFCIC and Work Groups should be avoided.

S-45 suggested a program of such a nature as to provide more discussion. The topic of winter perennial grasses was suggested, including orchardgrass, bromegrass, and tall fescue. It was suggested that the 1972 meeting at Clemson concern bermudagrass, allowing tall fescue to be featured during 1973 at Lexington. A systems approach in forage production, including forage handling and storage was suggested. The status of the many warm-season, perennial grasses was queried. It was agreed that the 1972 topic for SPFCIC Program will be warm-season, perennial grasses, including overseeding and interseeding of legumes and other grasses. Program Chairman Timothy will attempt to achieve a balance among work group interests in this topic.

A discussion followed on certain aspects of the selected topic. Problems in management of the grazing of warm-season, perennial grasses was suggested. Physiological differences between cool-season and warm-season grasses were queried.

Presentation of "breakthroughs" in different disciplines was encouraged. Aromatic compounds and animal preferences were suggested as of interest. It was emphasized that the selected, sub-topics should be of depth and a challenge to those in the immediate discipline. Some stated a preference for the later week possible for the Clemson 1972 meeting. Meeting dates with other groups should be avoided inasfar as possible. Dairy Science meetings are the third week of June.

The meeting was adjourned at 10:00 P.M.

Addendum —

In a letter from Dr. James E. Halpin of Clemson University, dated August 12, 1971:

"We look forward to having the group at Clemson for the 1972 meeting and have placed it on the University calendar for the week of May 15-19. Tentative schedule has Monday and Friday as "travel days" with sessions on Tuesday, Wednesday, and Thursday. Your committee will work out details later."

SOUTHERN FORAGE BREEDERS' WORK GROUP
July 6, 1971

Charles M. Taliaferro, Presiding

The Role of the Plant Breeder on the Maintenance of Germplasm

R. C. Leffel
USDA, ARS, PSR, Beltsville, Md.

Tinker (1971) cites Melville's work at Kew, the compilation of endangered plant species, as estimating that about 10 percent of our global flora is now threatened with extinction. Thus 20,000 plant species compares with 350 bird and 280 mammal species in danger of extinction.

Crop germplasm is defined by Creech and Reitz (1971) as "the array of plant materials, assembled or not, that serve as a basis for crop improvement, or related research." Frankel (1970a) distinguishes five more or less distinct kinds of germplasm material: (1) cultivars in current use, (2) obsolete cultivars, (3) special genetic stocks, (4) primitive varieties or land races, and (5) wild and weed species related to cultivated species. The loss of habitats as a consequence of the technological age threatens especially the primitive and wild plant materials related to our cultivated species.

Progress via plant breeding is dependent on genetic variation. Much less clear are the origins and sources of genetic variation within plant species. Durant (1962) cites the induced heritable changes reported in the literature, most of them being found in microorganisms. Bill Rumball of New Zealand, a visiting Research Fellow at Cornell University, 1970-71, recently summarized the literature on environmental induction of heritable changes in plants, and this subject always jars Mendelians. Estrom (1968) presents a speculative and startling model "in which the chromomere in the chromosomes of higher cells contains information on the frequencies of different alleles in the population. Its molecular basis is a master-slave arrangement with the slaves derived from previous meiotic partners. The model can explain several features of the genetic adaptation of higher organisms." Bennett (1965) presents a discussion of variability and adaptation and concludes that despite recent advances in molecular biology, our concepts of heterosis, homeostasis, flexibility, co-adaptation, genetic assimilation, and epigenesis are largely uninterpretable in terms of current information on the nature and action of genes. It is equally obvious and agreed that our scant knowledge on sources of genetic variation should prevent us from risking the future of plant breeding by loss of possibly irreplaceable germplasm.

The FAO/IBP Technical Conference on the Exploration, Utilization and Conservation of Plant Genetic Resources in 1967 is now available as IBP Handbook No. 11 (1970). A reading of the 44 papers in this "Genetic Resources in Plants - Their Exploration and Conservation," presented in the six sections of (1) biological background; (2) tactics of exploration and collection; (3) examples of exploration; (4) evaluation and utilization; (5) documentation, records and retrieval; and (6) conservation, by outstanding scientists of many nations, leaves little to say except -- "Let's get the job done!!" The plant breeder has a definite role and responsibility in the maintenance of germplasm.

Bennett (1965) presents sufficient indictment to raise the hackles of plant breeders in her discussion on genetic conservation and the future of plant breeding. Modern crop production has demanded uniformity and maximum production, and the narrowing gene base for many of our crop plants is the inevitable result. We are all familiar with the current threat to our maize crop through the use of a common cytoplasm; perhaps fewer of us realize the impact of singlecross hybrids instead of doublecrosses in recent years and the subsequent reductions in genetic variability, and the continuously narrowing gene base due to fewer, more closely related inbreds producing most of the maize crop of the United States.

Bennett (1965) attributes lack of response to selection as a consequence of narrow genetic base and condemns the monogenic, versus polygenic resistance breeding in small grains. She considers monogenic resistance breeding as a cat and mouse game, contributing to continuous and heavy disease losses, and giving no stimulus to genetic variability. Genetic erosion is attributed to the loss of habitats and wild, primitive and other plant materials, and to the narrowing gene base due to plant breeding methods. Perhaps we should also add "forage breeders and forage breeding programs" to the erosion scene. We are being eroded, are we not!!

Bennett (1965) concludes: "It is as tragic, indeed, as it is astonishing that, with the enormous genetic potential available, the most permanent achievement of modern plant breeding with all the equipment of genetics at its disposal appears to be the loss or destruction of much of the world resources of genetic variability." Plant breeders can question such condemnation; we can consider others more responsible than we; we can require proof of <u>what has been lost</u>; we can argue that loss is part of the evolutionary game. But as plant breeders we revere genetic variability and we forgive, and will help, those who have failed us!!

Frankel (1970b) discusses the principles and methods of conservation of wild and primitive gene pools. Wild communities need be preserved; gene-pool conservation is concerned with genetic differences which often can only be surmised but not identified. "A 'genetic reserve' should include a spectrum of ecological variability so as to provide a spectrum of genetic variability." Conservation of primitive cultivars <u>in situ</u> does not appear practical and conservation in collections presents many problems. In collections, some compromise must be made between individuality and panmixis. Changes in population structure can occur through national selection, genetic drift, outcrossing, and loss of ill-adapted types. Optimal long-term seed storage facilities will reduce these restrictions to conservation. Preservation of

a collection _is_ compatible with its utilization. As for panmictic populations, as mass reservoirs, Frankel (1970b) states: "The question here is whether genes and gene combinations can be retained which do not confer an advantage under the particular conditions of environment and population structure. This clearly is an essential requirement of long-term conservation, as distinct from adaptive populations serving relatively short-term objectives. --- It is, in fact, the fate of gene combinations and of gene complexes under conditions of competition and of recombination that raises the gravest doubts about the appropriateness of mass reservoirs for genetic conservation."

Frankel (1970b) calls for an action program for genetic conservation. First, we need an inventory of genetic resources in the field, followed by concerted action in plant exploration and collection and in utilization and conservation of germplasm. Documentation of collections is essential, as is international coordination and cooperation, for the conservation of the world's genetic resources.

Treatment of wild and primitive plant materials caused me to review the literature on wild red clovers of the world. I fear that the term "wild" has been used somewhat indiscriminantly. Lissitzyn (1933), Nuesch (1960), Julen (1969), Merkenschlager (1934), Wexelsen (1966), and Williams (1945) are in general agreement on characterization and character associations of cultivated red clovers, and all have examined and discussed wild red clovers. Lissitzyn, a contemporary of Vavilov, presents the most startling argument for wild red clovers. From 1922 to 1929, Lissitzyn (1933) collected 194 samples of wild (indigenous) clover from the whole of U.S.S.R., in a series of seven collecting expeditions. The complete work (published, in Russian, 1934) includes a map locating each accession. Lissitzyn concludes that the wild clovers range continuously from early to late flowering ecotypes, that they exhibit no relation between time of flowering and persistence nor between time of flowering and the ability to form aftermath, and that the wild red clovers are superior to cultivated red clovers for increased leafiness, winterhardiness, resistance to Fusarium, tolerance to flooding, and persistence. "Cultivated clovers should be abandoned for use on pastures. --- (one's) conception of red clover and its characters has been deduced from the observations of cultivated clover, and -- he knows nothing about wild clover." I find this account puzzling in that we have capitalized on such germplasm to no degree whatever. The character associations mentioned also suggest some support for the concept of genetic engineering. I anxiously await the wild red clovers of the world.

Perhaps breeders of forage crops and forest trees are working with wilder, more primitive germplasm than are breeders of our principal food crops. Most scientists accept the inevitability of some compromise in the maintenance of germplasm of our cross-pollinated crops. What appears to me to be an excellent and reasonable compromise in the maintenance of germplasm of cross-pollinated forages is that by Hanson et al. (1971). This proposes a worldwide collection of alfalfa germplasm with subsequent provisions for inputs from future collections. Germplasm is selected from the worldwide collection, on the basis of regional adaptation and needs and for a designated ratio of exotic to domestic materials, for each of seven geographic regions in the country. Thus each of seven regional gene pools is developed by recombination and mild

selection. New germplasm (subsequent collections) is incorporated into regional pools once in every 5 years, again in a designated ratio. On the basis of winterhardiness, seed of certain regional gene pools is composited for a subsequent intermating of the populations concerned. The seed harvested constitutes the germplasm for each of three world gene banks, (hardy, intermediate, and nonhardy). Again, the proposal provides for systematic incorporation of new germplasm into the world gene banks. The proposal defines the development of regional gene pools and world gene banks as the joint responsibility of plant explorers and plant breeders. Plant explorers will be responsible for plant exploration and collection, and for distribution and storage of seed. Breeders will be responsible for the development of regional pools.

Especially lacking in the philosophies on conservation of germplasm is a specific plan such as outlined above by Hanson et al. (1971). Creech and Reitz (1971), in discussing programs for the future, state: "We have now reached a time when serious consideration needs to be given to the direction our overall activities in germplasm will take. The question is not so much what we can do, but whether the priorities that will be assigned by scientists and administrators to the conservation of germplasm will meet the goal." It is obvious to me that the concerted effort of plant introduction and plant breeding specialists is a requirement for progress in the maintenance of germplasm.

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The National Program of Collecting, Cataloguing, Storing, and Distributing Germplasm

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Under the Research and Marketing Act of 1946 funds were made available to establish a cooperative Federal-State program for the introduction and evaluation of plants for agricultural and industrial uses and for the preservation of valuable germplasm. Under this program the New Crops Research Branch is responsible for exploring the world plant resources and introducing new stocks. State experiment stations and other cooperating agencies are responsible for evaluating the new stocks.

For convenience in coordinating the national cooperative program the United States is divided into four regions - Northeastern, North Central, Western, and Southern - each with a State-Federal cooperative project. In each region there is a regional plant introduction station with a coordinator to supervise its activities and, with the aid of a technical committee, to coordinate research and evaluation of plant introductions within the region. The program is coordinated on a national level through cooperation among regional stations under direction of the New Crops Research Branch and the National Coordinating Committee representing the four regional projects.

Germplasm is obtained (1) by plant exploration, (2) through PL 480 contracts, (3) through US/AID Missions, (4) by international exchange of seed through correspondence, and (5) from other scientists who travel abroad. Explorations are based on regional needs, and requests from both State and Federal scientists are considered in planning explorations.

Propagation, preliminary evaluation, cataloguing, distribution, and preservation of introduced stocks are functions of the regional plant introduction stations. Plantings made for seed production are observed for desirable agronomic and horticultural characteristics. Through use of automatic data processing equipment these observations are summarized and a catalogue of available materials is prepared periodically. Catalogues are exchanged among regional stations, and copies of each are sent to each State station. Consequently, seed and plants maintained at any regional station are readily available to plant scientists in any of the 50 States and Puerto Rico.

Presently there are more than 7,000 accessions of forage grasses and legumes maintained at the Southern Regional Plant Introduction Station. These represent more than 100 plant genera and several hundred species. Other collections similar in size and diversity are held at each of the other regional stations.

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Methods of Preserving and Utilizing Genetic Diversity in Germplasm

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A plant breeder's success is largely dependent on the diversity of germplasm available. Recognizing this truth, breeders and agencies have developed world collections of economically important crops. Such collections indicate the potential of the species, may supply a superior variety without change, provide useful genes such as pest resistance, dwarfness and hardiness for existing varieties and often permit greater heterosis. When properly grouped into pools, these accessions can buffer against hazards and evolve superior types.

Germplasm may be preserved by maintaining living cultures, isolated seed increase, selfing or sibbing each accession, hybridizing accessions, developing germplasm mixtures or pools and long-time storage. Cross-pollinated annuals can only be maintained in storage by isolated increase. The latter is impracticable. Selfing or sibbing results in a loss of vigor and genes. Gene pools usually lose genes and often obscure hard-to-recover traits. Thus long-time storage offers the only practicable means for germplasm maintenance.

To utilize genetic diversity in germplasm, we must collect it, assess it, catalog it, preserve it, know it, use it and share it. The plant breeder can afford to do all of these if need be. If his collection is large and well assessed and if he knows how to manipulate it, he can transfer to otherwise good varieties useful genes for pest resistance, hardiness, desired plant structure, earliness or lateness, high digestibility, etc., by hybridization. Crossing introductions with elite lines before inbreeding can result in superior inbreds with better combining ability than the original elite line. Diallel performance can be used to select parents of cross-pollinated crops for the development of commercial first-generation synthetics such as Gahi-1 pearl millet. If the species can be propagated vegetatively, wide crosses that result in sterile hybrids can be used to bring together desirable characteristics and give a high degree of heterosis. Sterility will reduce pest potential, facilitate control and usually enhance forage quality.

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The National Seed Storage Program at Fort Collins

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Most crop specialists in the U.S. are aware of the value of introduced plant germplasm as contributing to improved crop varieties and agricultural production during the past century. They are not, however, fully aware of their responsibilities as trained scientists to maintain and preserve such material for future contingencies. In the early days of crop improvement, there was plentiful sources of supply throughout the accessible world, but many such sources are rapidly dwindling for various and obvious reasons. The idea of a

National germplasm bank was brought into focus in 1944 when the National Research Council recognized the need for preserving open-pollinated lines of corn which were the nucleus for the commercial hybrid corn industry.

An important adjunct to the program was a facility for long term seed storage. When the Research and Marketing Act of 1946 became law, one objective was increased emphasis on a national cooperation program covering the introduction, testing and maintenance of basic breeding stocks based upon a regional approach. This was the origin of our regional plant introduction stations. It was evident, also, that the "maintenance" aspect would require an adequate and efficient long-term seed storage facility. Many meetings and discussions were held based upon the objective that long-term storage was needed for genetic stocks of interest to research workers in plant genetics and related disciplines, for breeding stocks believed of value because they contain superior germplasm, and for primitive species which may contain germplasm for specific characters. From the several locations initially suggested, Fort Collins, Colorado, was selected for the Laboratory due to the dry atmospheric conditions that would permit operating with a minimum of temperature and humidity control.

The basic proposal for the NSSL was first submitted to Congress during the winter of 1954-55 requesting $450,000 for construction and operation. After additional budget hearings and a receptive Congress, the Seed Bank Appropriation bill was signed by President Eisenhower in May 1956. Construction was started in the spring of 1957 and the Laboratory was dedicated December 5, 1958. Dr. Edwin James was appointed Head of the facility.

During the early years informal crop subcommittees were appointed to recommend what materials should be placed in storage. Also, a Seed Storage Advisory Committee was established in 1957 to set up policy and operational patterns. This committee was dissolved in the early 1960s and a revision of NSSL policies was prepared in June 1967 by an "ad hoc" group.

At present there are 81,000 accessions in NSSL with the World Collection of Small Grains being the largest segment. Large collections of corn, tomatoes, soybeans, cotton, peanuts, and tobacco are included. The nine rooms available for storage have a capacity for 300,000 samples of 1-quart size. The various categories solicited for storage are (1) newly released varieties, (2) current varieties, (3) open-pollinated varieties, (4) inbred lines, (5) obsolescent germplasm, (6) genetic stocks, (7) plant introductions, (8) differential host varieties, (9) virus indicator stocks, and (10) physiologically useful species. Inventories of seeds deposited have been prepared periodically covering corn, cotton-fiber, forage crops, genetic stocks, oilseeds, ornamentals, small grains, sorghums, sugar crops, tobacco, and vegetables.

Sufficient seed is required for initial storage to permit periodic germination tests at two or three year intervals. Originally, standards were set for a minimum of 5,000 seed per sample. The interval may be extended based upon accumulative data for specific crops. Basic research is conducted on effects of vacuum and inert gases, flexible packaging materials as moisture barrier containers, and longevity of specific crops as related to specific temperature and humidity readings as well as growing environment.

NSSL will likely become involved in storage of crop varieties to be registered under the new Plant Variety Protection Act. Arrangements are underway to accept samples of the American Type Culture Collection, All America Selections, and referee sugarbeet samples for that industry. Germplasm collections resulting from U.S.-sponsored programs abroad such as Public Law 480 and AID activities will be stored in NSSL when desirable.

During the period when the seed storage facility was being approved, the need for national repositories of asexually propagated stocks also was recognized. Forage and turfgrasses were among the groups initially discussed, but first priority was given to fruits. The initial report and objectives appeared November 1958 from a subcommittee on a "National Repository for Asexually Propagated Plants." Numerous meetings and discussions followed through 1968, including estimated costs, land requirements, and suitable locations but the only tangible progress made was surveys and published inventories covering domestic collections of apples, stone fruits, pears, and related fruit clones. Approval of such repositories by researchers in general was quite favorable, and recommendations were passed to higher administrative levels but no forthcoming support has been indicated.

Note: A copy of the National Seed Storage Laboratory Policies Statement is available from Mr. Hyland.

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Some International Programs and Problems of Plant Exploration and Introduction

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Some International Programs of Interest are:

1) The Rockefeller Foundation interest and support in assembly, maintenance and utilization of the gene pools for Maize, Wheat, Rice, Sorghum and Millets. These collections are currently being assessed and definite steps are planned to improve the collections with respect to completeness, maintenance and use.

2) The FAO activities have included the development of an International Center at Izmir, Turkey, and the establishment of a Crop Ecology and Genetic Resources Unit in the Plant Production and Protection Division. This unit has been involved in coordination of expeditions, assistance to collectors, documentation, storage, distribution and exchange of seeds. Plans are for the development of a global network of plant introduction centers coordinated but probably not financed by FAO.

3) Eucarpia, the European Association of Plant Breeders has plans for some three gene banks to serve Europe, one for Scandinavia, one for mid-Europe, and one in Italy for the Mediterranean region. The Italian station is already operational for some materials. An European potato collection is also proposed which will have close relationship to the

Sturgeon Bay, Wisconsin, station.

4) Other efforts include a first-class UNDP supported facility in Bulgaria, some closer cooperation with the USSR, and IRAT activities within the French Union.

Some International Problems:

1) New plant quarantine regulations will make it very difficult to introduce many kinds of materials into the U.S. from Asia and Africa. The effectiveness of plant introduction and distribution centers as sources of material will probably be seriously impaired. Many countries tend to follow the U.S. lead, rightly or wrongly, and we may predict serious interruptions in the flow of materials on the international scene.

2) There is some reason for tightening quarantine regulations. Diseases and pests are being distributed, not necessarily by Agronomists, but exchange of some materials should be more carefully controlled than it has been in the past.

3) Success is wiping out genetic resources in some crops. The wheats are in particular danger at the present time. The Mexican wheats have washed across Asia with incredible speed replacing much of the diversity once available. In many areas it is already too late to salvage anything not already in the world collections. Other crops are likely to follow the same pattern. Forage resources are increasingly threatened by overgrazing.

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SOUTHERN FORAGE PHYSIOLOGY AND ECOLOGY WORK GROUP
July 6, 1971
C. C. King, Presiding
Do We Need Legumes In Pastures?

A. E. Kretschmer, Jr.
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Introduction

The climatic conditions encompassed by the workers in the States involved in the Southern Pasture and Forage Crop Improvement Conference are diversified and difficult to assess in simple terms. Availability of artesian, surface, or impounded water also is extremely variable throughout the region. At one extreme the State of Florida (particularly the southern peninsula) has a very mild winter climate. It receives high summer rainfall from about May or June until December with less rain normally falling during the rest of the year. The driest part of the year generally is from March until the first rains in the spring. Certain areas bordering the Gulf of Mexico in other States would have climates not unlike that of Florida except winters are more severe. Florida is also blessed with an abundance of surface and artesian or other types of usable well water. Many of the other States can be characterized by rather severe winters, abundant precipitation during this period and usually some rainfall in the summer. However, in many instances, summer rainfall patterns are erratic and generally dry periods of up to a month or so can occur during the summer.

In spite of these differences, of the major legumes that have been or are being mentioned as pasture crops, (Rose, Crimson, Bur, Persian, and Alsike clovers) white clover has proved to be far more successful than any other grazing-type legume. The other major legume, used more for hay, is alfalfa. However, the incidence of the alfalfa weevil has tremendously reduced the alfalfa acreage during the last several years particularly in the eastern part of the area.

A great deal of emphasis has been placed on the desirability of including white clover and other clovers in permanent grass pastures. Successes with white clover have been sporadic in most of the areas included in the southern region. The two major factors for success or failure are management practices and climate. It has been shown that white clover can markedly increase both yields of dry forage, nitrogen content and beef gains per acre at a cost considerably less than that of nitrogen fertilized grass pastures. On the other hand, there are numerous localized areas where the production of white or other clovers would be impossible, primarily due to the lack of sufficient moisture during the growing period. In many instances, there is a lack of desire by the commercial operator to grow legumes, especially when the attributes of applying nitrogen are highly publicized.

Contribution of Legumes to Dry Matter Production of Pastures

Generally, perennial grasses fertilized with heavy quantities of nitrogen produce more dry matter during their maximum period of growth than do permanent pastures composed of legumes and grasses during the legume maximum growth period. In reviewing the literature it appears that from 400 to 600 pounds per acre per year of nitrogen can be utilized by most of the rapidly growing grasses now being used in the area. More than a ton of beef per acre has been produced with these rates in Australia. Because of the ability of grasses to respond to nitrogen it is generally easier to regulate dry matter production through the use of nitrogen applications than through the use of legumes. On the other hand, increasing nitrogen rates on grass pastures does not generally affect the beef gain per animal per day but rather affects the total beef gains per acre (stocking rate and total beef production per acre are increased). Also, the use of large quantities of nitrogen on grass pastures is questionable from the economic standpoint under many management systems.

Legumes can add to the dry matter production on legume-based grass pastures compared to grasses not fertilized with nitrogen. Legumes can also add to the dry matter production during periods unfavorable to grass production. For example, white clover grows rather well in south Florida during winter months when the grass varieties now being used are dormant. This is true for certain other areas in the southern States during spring months. Tropical legumes are not being used extensively in the southern region at present; but because of their rather remarkably high drought resistance they could add to the production if included in grass pasture systems. Regardless of the pros or cons of utilizing legumes in pastures, there is no doubt that the complete farming system within a ranch could not generally be based entirely on one legume-grass mixture. The reason for this is the almost impossible management necessary to maintain the clover content in all of the grass pastures. It would be better to consider legume-based pastures as one part in an overall management system.

Contribution of Legumes to Quality

There is universal acceptance that the temperate legumes (clovers, alfalfa, etc.) are highly digestible. This digestibility will average from 60 to 80% of digestible dry matter. There is little doubt that the intake by the animal of these legumes is much greater than the tropical grass species and generally higher than the semi-temperate species (tall fescuegrass, Coastal bermudagrass, etc.).

In addition, there is an added response, at least to white clover, with respect to breeding habits in cows. Florida work has shown increased pregnancy rate for lactating cows grazing white clover-grass pastures compared to grass alone. Calf weaning weights were also greater. It has also been found, in Wales, with perennial ryegrass receiving maximum utilizable rates of nitrogen, that beef production increased whenever white clover was included with the ryegrass. This was believed to be the result of the high content of fermentable carbohydrates which affected the rumen wall

characteristics and the amount of its contents.

Considerable work has been done in Australia on the quality of tropical legumes compared with tropical grass species such as pangola, guinea, para and others. It has been found in grasses, that crude protein content, per se, when about 7% or above has little effect on animal intake. Below 7%, intake is reduced in a straight line manner with decreasing crude protein contents. Although the crude protein contents of tropical legumes vary from approximately 14 to 25%, the digestible dry matter of these legumes is very similar to those of the tropical grasses in immature stages of growth. However, the crude protein and quality of these grasses decrease rapidly with age while these factors in tropical legumes are maintained for much longer periods. It has been found that the intake of energy (also intake of dry matter) of tropical legumes is much greater than tropical grasses having equal digestible dry matter contents.

Fixation of Nitrogen by Legumes

One of the uncontested benefits of both temperate and tropical legumes is their ability to fix nitrogen from the atmosphere. Under commercial conditions in the Southeastern States results have indicated that from about 100 to 200 pounds of nitrogen per acre per year can be fixed by white clover. Work in Florida has indicated that several of the tropical legumes such as S. humilis, Siratro, Glycine, and Centro growing in combination with pangolagrass or bahiagrass will produce about 100 pounds of nitrogen per acre per year in the above ground portion.

Experimentally it has been shown that the maximum fixation of nitrogen per acre by both temperate and tropical legumes may reach about 400 pounds per acre per year.

Effect of Legumes on Animal Production

Scattered reports are available where comparisons of grass versus grass-legume mixtures were made with respect to beef gains.

The legumes (both tropical and temperate) added to grass pastures usually compare favorably to grass alone fertilized with 100 to 200 pounds of nitrogen per acre per year. Beef production per acre from grass more heavily fertilized with nitrogen usually is greater than that from grass-legume mixtures.

The aspect of grass competition on legume growth should be given additional emphasis. Since the advent of the newer, more rapidly growing grasses of the last two decades, there has been a decrease in the use of legumes in many parts of the southern area. Do these newer grasses add to the management problem of maintaining a satisfactory legume component? It is of interest to point out that considerable work was done in the 1940's and 1950's in Florida comparing beef cattle gains on white clover-carpetgrass pastures. Beef gains per acre per year (or less) on this mixture averaged more than 600 pounds in one experiment and as high as 800 pounds in a second

3-year test. These are equivalent or better than beef-yields reported for grass pastures receiving 200 to 400 pounds of nitrogen per acre per year.

Future Emphasis with Legumes

Although there are many situations where legumes cannot be used in permanent pastures in the southern States, it is believed that continued work with legumes will result in better utilization and better longevity of the legume in the grass pasture. Use of more than one legume in grass pastures may find favor with commercial operators. The use of legumes will continue to increase in areas where their ease of establishment and maintenance in permanent pastures does not require undue management practices. There will be continued breeding work with temperate legumes and there should be additional work on the grass competition effect on legumes.

There appears to be a good potential for the use of tropical, summer-growing legumes in many of the southern States. Work in Florida and Georgia has indicated the possibilities of utilizing some of the more tropical species, especially when a breeding program is used in conjunction with an evaluation program. Genera, such as Centrosema and Stylosanthes offer a large range of germplasm for breeding work. Both these genera are represented by native growing plants in most of the southern and even semi-temperate areas of the United States. The main problem with the tropical species is the inability to produce sufficient seeds in the more northern areas of southern United States. The potential of Dolichos lab lab and possibly other annual summer-growing legumes is rather large. There is the distinct possibility of the use of these annuals in place of some of the summer annual grasses. Seed costs are very competitive.

The ultimate use of legumes in the United States is still based on the value that the commercial user places on them. This in turn depends on the availability of the seeds, growth rates, ability to persist, and ease of establishment and maintenance.

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White Clover in Perennial Summer Grass Sods

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I have attempted to review the pertinent literature from the Southeast on establishing, maintaining, and utilizing white clover in perennial summer grass sods.

In Alabama we have found that use of an insecticide and/or irrigation will aid in establishing and maintaining white clover. Complete land preparation is not necessary if a herbicide is used to suppress the grass. The insect causing establishment difficulties is the striped field cricket (4 and 8).

Proper attention to pH and fertility is important in white clover-perennial summer grass production (3). Spooner and Clary (12) have shown that as N is increased, percent white clover in the sward is reduced. Chamblee (2) reported that distribution and total yield were increased when white clover was grown with dallisgrass.

Hogg (6) found that the percentage of clover was markedly reduced by increasing the height of cut of the clover-grass sward. He concluded that where there is a good stand of white clover in Coastal pastures, no economic response to applied N will occur until late summer. Hogg (5) also reported beef gains from bermudagrass and white clover of over twice that of bermudagrass + 120 lb. N/A. Pund and Hogg (11) found Coastal + 200 lb. N/A to be somewhat better than Coastal + white clover with respect to steer grazing days/A and live wt./A. Beef gain/A was about equal; ADG was in favor of Coastal + clover and pasture cost/lb. of gain was only 1/2 of that when 200 lb. N/A was used on Coastal.

Browning et al., (1) showed Ladino clover alone superior in milk production and persistency to clover + Coastal which were in turn superior to Coastal alone. Ward and Watson (13) showed bermudagrass + Regal to produce more gain per animal with twice the returns per acre as bermudagrass + N. This ties in with other economic research by Hogg and Collins (7) which showed cost/lb. of gain when Ladino or La. S-1 was grown with Coastal to be about 1/2 to 1/3 of that of other systems tried. The white clover systems were better also from the standpoints of lb. of beef/A, ADG, and animal days grazing/A.

Some of the classical research that shows the benefit of white clover was done in Florida by Koger et al. (10). They found a lower pregnancy rate in cows on grass pastures because of failure of nursing cows to come into estrus rather than failure to conceive when bred. They concluded that the cost of producing beef, in a cow-calf enterprise, from a grass/clover sward was approximately 60% of that from pure grass.

Two deficiencies of dallisgrass-white clover in Alabama are low carrying capacity and a rather long unproductive season. By replacing some of the normal allocation of dallisgrass-white clover with fescue we were able to reduce the number of days fed hay, but hay was still required each year (9). Calf weight/A was significantly higher for Coastal-caley peas, but weight/-calf was significantly lower than for the other systems, which did not differ among themselves. Returns to operator's labor and management/A did not differ greatly among the four systems.

(1) Browning et al., 1962, Sou. Ag. Workers 59th Conv.; (2) Chamblee, 1960, N.C. State Bull. 411; (3) Ensminger and Evans, 1960, Auburn Bull. 327; (4) Evans, 1965, Ala. Highlights of Ag. Res.; (5) Hogg,1965, 9th Int.Grsld.Cong.; (6) Hogg, 1967, Miss. Fm. Res.;(7) Hogg and Collins,1965, Miss. Fm. Res.; (8) King et al. 1968, Ala. Highlights of Ag. Res.; (9) King et al.,1971 Auburn Bull. (in press); (10) Koger et al., 1961,Fla. Bull. 631; (11) Pund and Hogg, 1969, Miss. Fm. Res.; (12) Spooner and Clary, 1962, Ark. Bull. 658; (13) Ward and Watson, Jan. 1971, Farm Technology.

Perennial Legumes for Pastures in the Lower South

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White clover (Trifolium repens) is the most widely used perennial legume in the lower south. In fact, it is the only perennial legume commonly exhibiting a perennial habit in pastures below the 35th parallel.

Many Agronomist would argue that white clover acts as a winter annual in the Southern States rather than a perennial. The inability of white clover and other legumes to consistently persist through the hot summer months in the south is well documented.

New varieties of white clover like Regal and Tillman are much more drought and heat tolerant than commercial ladino or Louisiana S-1. The latter is at its best in the extreme lower Coastal Plain. Its ability to persist is linked to the profusion of seed produced in the spring season.

Regal on the other hand is a sparse seeder but persists as stolons much better than La S-1. In tests at State College, Mississippi, Regal produced about 40% more seasonal yield than La S-1; in the period June 15 to September 15th Regal produced about six times more forage than La S-1.

In the lower south, white clover does well with dallisgrass, tall fescue, bermudagrass and bahiagrass. It performs best with dallisgrass and tall fescue, followed by bermuda and bahiagrass.

In tests at State College, Mississippi, we have found tall fescue and ladino clover to be an excellent combination. Regal white clover persisted better when the fescue was planted in 10 to 20 inch rows than when broadcast seeded. A more desirable botanical composition was maintained when a cutting height of 2" (as compared to 1 to 3 inches) was imposed with sufficient frequency to prevent severe shading by the fescue.

A 4-year study at State College, Mississippi, showed white clover (La S-1) with coastal bermudagrass, Pensacola bahiagrass and dallisgrass produced yields equivalent to the grasses alone with 120 lbs. of N.

White clover persistence in the lower south seems to be related most to available soil moisture during July and August. The exception of this would be in peninsular Florida where loss of stands occurs because of late winter droughts.

Red clover (Trifolium pratense) has shown promise as a pasture legume in certain parts of the lower south and though short lived appears to have a definite place in the south.

Persistence of white clover in the lower south is also related to the use of lime, phosphorus, potassium and sometimes trace minerals.

Reseeding of white clover into pastures where stand failure has occurred is a common practice. The pasture to be seeded is grazed closely or clipped by broadcasting or drilling the clover seed in early fall.

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Legumes in Perennial Cool-Season Grass Sods -- Upper Southeast

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Cattle numbers in the Upper Southeast States of Arkansas, Kentucky, North Carolina, Oklahoma, Tennessee and Virginia increased from 11.23 million head to 14.66 for the period January 1, 1961, to January 1, 1971, an increase of 30%. The class of cattle with the highest rate of increase was beef cows 2 years of age or older which increased by 2.38 million, or by 63%. Increases of all cattle numbers and all hay production over the past decade are given by States in Table 1.

Table 1. All cattle on farms January 1, 1971, and 10-year increase and increase in all hays produced from 1959 to 1969*.

	Cattle (1,000)	Increase over 1961		All Hay (1,000 Tons)
State	1971	Actual	%	Increase over 1959
Ky.	2,859	744	26	761
Ark.	1,787	399	30	113
N.C.	1,081	183	20	-625
Okla.	5,085	1,572	45	1,118
Tenn.	2,354	440	23	7
Va.	1,489	81	6	34
Total	14,655	3,419	30	

* Agr. Stat. USDA 1960,1961, 1970, and 1971. Hay data for Kentucky were taken from Hay Prod. and Marketing Survey, Ky. Agr. Exp. Sta., 1970.

Kentucky cattle numbers increased during the sixties by 744,000 head, of which number 531,000 were beef cows 2 years of age or older. From 1959 to 1969 grass hay production increased by 1,000 tons while legume and grass-legume hay increased by 760,000 tons, and acres of renovated cool-season grass sods increased from 36,000 in 1960 to 750,000 in 1970. Thus, for each head of cattle added Kentucky farmers harvested an additional ton of grass-legume hay and renovated approximately one acre of cool-season grass sod.

The changes in areas of legume and legume-grass hays from 1959 to 1969 were that alfalfa decreased by 92,000 acres, lespedeza-grass by 189,000 acres, but clover-grass increased by 315,000 acres. Yields of all legume-grass hays increased by 0.48 tons per acre over the period. The net effects were that farmers were using 70,000 more acres for grass-legume hay production but

were producing 760,000 tons more grass-legume hay in 1969 than they were in 1959. The production of grass hay remained essentially unchanged.

The alfalfa weevil continues to render great damage to the alfalfa crop, and until better control is available it appears that Kentucky acreage will remain at about 200,000. Advanced pasture studies conducted by the Kentucky station have indicated the possible use of birdsfoot trefoil and big-flowered vetch with cool-season grasses, especially on rough hill land. Workers at Kentucky have developed a new variety of red clover and it will be available for farmer use by 1974. Encouraging progress is being made on developing a creeping-type alfalfa.

Arkansas gained 399,000 head of animals from January 1, 1961, to January 1, 1971, and all hay production increased by 113,000 tons, an increase of 0.3 tons for each head of cattle increase. Dr. Art Spooner writes:

> "Our most used perennial cool-season grass is tall fescue and the most used legume is white clover. We do not use much alfalfa and red clover since our major program is beef cattle. We are using primarily Regal white clover but some ladino and LA S-1 are being used. We recommend that white clover be seeded with all cool-season permanent grasses. I feel that the use of legumes is increasing in Arkansas. We overseed tall fescue with annual lespedeza where we are not using high levels of fertilization."

In a private conversation with Dr. Spooner, we learned that stockpiling tall fescue in the field for winter grazing is a common practice in Arkansas. This practice may account for the low tonnage of hay harvested per head of animal increase in Arkansas.

North Carolina gained 183,000 head of cattle and decreased hay production by 625,000 tons. Dr. Doug Chamblee writes:

> "Relative to the subject Legumes in perennial cool-season grass sods, we are utilizing primarily tall fescue, orchardgrass, or Kentucky bluegrass as our cool-season perennial grasses. Our new seedings are usually of tall fescue or orchardgrass with ladino clover. In recent years serious difficulty has been encountered in many parts of the State in maintaining stands of ladino clover. Our best performance of ladino clover continues to be in the Tidewater area of the State on soils of high organic matter content and high moisture levels. In these areas ladino persists at least 5 years. I have enclosed a financial statement of a farmer in the Tidewater area who has 3/4 to 1 acre of ladino-tall fescue per animal unit. Last year he received a net return of $50 per acre.
>
> "In other areas stands of ladino last usually from 2 to 3 years. We have not identified the main causal agent. Many diseases and insects attack ladino, in our area. Other factors, such as grazing management and lack of proper fertilization, enter the picture.
>
> "There are some farmers who are reseeding ladino into existing fescue or

orchardgrass sods with minimum-type seedbed preparation with varying degrees of success. This practice is being carried out on a limited acreage at present.

"Crownvetch shows some promise as a cool-season legume in experimental pastures. Usually it is seeded alone or with low rates per acre of cool-season grasses. Very few farmers are utilizing this plant. We sometimes note serious difficulty with disease with crownvetch under some managements. More and more of our farmers are utilizing pure grass pastures."

Dr. Chamblee indicated in the discussion period of the meeting that the loss of 625,000 tons of hay was due primarily to decreased alfalfa production in North Carolina.

Oklahoma gained 1.6 million head of cattle and increased hay production by 1.1 million tons, or 0.7 tons for each head of cattle increase. Dr. Loren Rommann writes:

"Your inquiry about legumes in perennial cool-season grasses has been given to me. The figures stated here are strictly estimates. I wish someone could get more accurate figures.

"An estimated 3,000 to 4,000 acres of irrigated smooth bromegrass-alfalfa pastures are being grazed in the Oklahoma Panhandle. These are stocker calf operations and the animals go directly to the feedlot for finishing. Because of the high irrigation costs, it takes top management to make a profit. Some pastures are being plowed and converted to corn or sorghum production. The trend is a slight increase in irrigated pastures for that area but the increase will be slow.

"In eastern Oklahoma, the only cool-season perennial grass of any current significance is tall fescue. We have an estimated 300,000 acres. Legumes (Ladino clover) are being attempted on at least half of this acreage but because of our periodic droughty conditions I doubt that over 20% has a satisfactory legume stand. We feel that legumes will not be dependable in areas of Oklahoma receiving less than 44 inches of rainfall. This covers about 90% of the State. Our official position is suggesting the use of nitrogen fertilizer instead of legumes."

Tennessee gained 440,000 head of cattle and hay production increased by 7,000 tons, or 30 pounds per head of cattle increase. Joe Burns writes:

"This is in response to your letter of June 18 concerning your question: How and what are you feeding the extra 440,000 cattle"?

"It seems that the increased use of fertilizer has been the main reason for added carrying capacity and extra feed needed by the additional 440,000 head of livestock. Renovation played a small part but fertilization was the main cause. Our best estimate is that Tennessee farmers were fertilizing about 15 percent of their pastures every year in 1960 and that in 1970 about 25 percent of the pastures were being fertilized each year. With approximately 5 million acres of pasture, this means that 750,000 acres were being fertilized in 1960 and 1,250,000 acres in 1970. This could mean that the extra 500,000 acres being fertilized

would have produced enough more feed to supply the additional needs of the 440,000 animals."

Finally, let's go to Virginia -- cattle numbers increased by 81,000 head and hay production by 34,000 tons, an increase of 0.4 tons of hay for each head of cattle added. The authors received no reply to their letter of inquiry, and no Virginia workers were present at the physiology-ecology meeting to give a report.

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Winter Annual Clovers in Perennial Summer Grass Sods

A. E. Spooner
University of Arkansas

The use of winter annual clovers in the South is apparently on the increase. This is due primarily to the increased use of permanent summer grass sods and to more extensively managed pasture programs. The increase in land values have caused the cattleman to make more and better use of each acre of land.

There are two clovers being used quite extensively at the present time. They are (1) crimson and (2) arrowleaf. I do not know the percentage being used of each in the South today, but if I were to guess, I would say that arrowleaf is gaining rapidly on the crimson. Farmers have told me that they get considerably more grazing from the arrowleaf and it apparently reseeds better under heavier grazing pressure. The trend in Arkansas is to arrowleaf and Yuchi is the variety being used.

One of the big problems in the use of winter annual clovers in a perennial summer grass sod is obtaining good germination early enough to get fall and early winter grazing. This is caused by two factors: (1) too much grass growth at seeding time and (2) lack of proper rainfall for germination and growth. We have found that we can not justify seeding these clovers if we can not get the fall and early winter grazing. Seeding methods play an important role in getting a stand also. We have found that most any seeding method (such as sod seeding, disking, and rolling, etc.) can be used provided the seed is in contact with the soil.

Reseeding has been a real problem with many of our livestock producers. They will not reduce their grazing pressure at the proper time to allow adequate reseeding. This lack of reseeding has been more of a problem with us on crimson than arrowleaf.

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Summer Legumes in Perennial Grass Sods

Ian Forbes, Jr.
USDA, ARS, PSR, Tifton, Georgia

Forage legumes in general have many desirable attributes: 1) the cheapest source of plant protein for ruminants; 2) the cheapest source of N for associated grasses; 3) less tendency than most mineral sources of N to lower soil pH; 4) higher forage quality than sub-tropical (and many temperate) grasses; 5) tendency to increase total animal intake of grass-legume mixtures; 6) tendency to increase animal daily gains; 7) tendency to increase milk-flow; 8) tendency to increase conception rate; 9) "minor" forage legumes are a germplasm reservoir for future major forage crops and vegetable protein and oil crops; and 10) former "minor" forage legumes in the U.S.A. include soybeans, peanuts, and southern peas (cowpeas).

Forage legumes in general face several hazards to their expanded, efficient use: 1) most mineral nitrogen fertilizers lower soil pH, sooner or later resulting in nutrient deficiencies (Ca, Mg, S, P, & Mo) and Mn toxicity; 2) soils low in native nutrients or naturally low in pH; 3) grasses that compete too strongly for available major, secondary, and micronutrients, and water, space, and light; 4) nematodes; 5) fungi; 6) viruses; 7) insects; 8) poor establishment and management techniques; 9) absence of any, or the best, *Rhizobium* strain for efficient nodules; and finally 10) the "grass + N" syndrome that involves agronomists (and supporting scientists), administrators, research budgets, and agri-business promoters.

Perennial summer legumes that are useful (or show promise for use) in perennial grass sods or else in pure stand as perennial sods include: *Desmodium uncinatum*, *Desmodium canum*, *Desmodium intortum*, *Desmodium sandwicense*, *Desmodium heterocarpum*, *Arachis glabrata* (et al.), *Phaseolus atropurpureus*, *Glycine javanica*, *Lotus pedunculatus*, *Lotus corniculatus*, *Lespedeza cuneata*, *Lotononis bainesii*, *Centrosema pubescens*, and *Medicago sativa*.

Annual summer legumes that are useful or show promise for future use in perennial grass sods include: *Arachis monticola*, *Stylosanthes humilis*, *Indigofera hirsuta*, *Aeschynomene americana*, *Phaseolus lathyroides*, *Lespedeza stipulacea*, and *Lespedeza striata*.

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SOUTHERN FORAGE EXTENSION WORK GROUP
July 6, 1971

The Oklahoma Extension Forage Program

Loren Rommann
Oklahoma State University

In a state that has over 14 million acres of native range, 7 million acres of commercial and non-commercial forests, 4.5 million acres of improved pastures and an average annual rainfall ranging from 56 inches to 16 inches, one cannot talk about a single extension forage program.

Different species of grass can be best utilized in different areas of the state. Oklahoma is fortunate to have high-producing introduced warm-season grasses adapted to most areas of the state. These include Midland and Coastal bermudagrass, weeping lovegrass, Old World bluestems and others. Cool-season grasses that are used include small grains, tall fescue, smooth bromegrass, and tall wheatgrass.

Sugar Drip forage sorghum grazed in situ can also be used to support the beef cow during the winter.

A more complete description of the resources and forage programs is reported in the presentations by Drs. Matlock and McMurphy.

During this past fall and winter several of the state extension staff and the area extension staff were involved in a series of bermudagrass shortcourses. This involved two to three sessions of two hours each, covering the fields of soil survey, soil fertility, weed control, bermudagrass establishment and management, other grass species to work into a pasture program, and livestock management. A charge of one dollar per contact hour was made to the participants.

Currently, a program is being planned for northeastern Oklahoma, an area that is not served by an area extension agronomist, to conduct demonstrations on several farms. These will be total farm forage demonstrations to improve the livestock enterprise and maximize the per acre return from the forage crops. It is hoped to have demonstrations involving different livestock operations such as the beef-cow operation under both a spring-calving program and a fall-calving program. A stocker operator could also fit into this program. One of the objectives will be to reduce the labor and cost of wintering the beef cow. Another major objective will be to demonstrate how the cow owner can sell these calves at 700 to 800 pounds, instead of 400 pounds. If there is money to be made with a stocker operation, then the cow owner should get in on part of this profit.

Some of the long-term objectives for the Oklahoma Forage Extension Program will be to continue teaching the proper management of both our native and introduced grass species such as bermudagrass, weeping lovegrass, and bluestems. Because of the high cost of land, this land must be put to its most

productive use. Some of the native range land and brush land in Oklahoma should be established to introduced grass species.

We also need to reduce the winter cow feeding costs through the use of cool-season grasses, forages sorghums grazed in situ, cheaper methods of handling hay or any other means. The long range emphasis will also see the cow owners selling calves at heavier weights.

It will be essential to have easily understood cost return data on all of the various range, pasture and forage programs and practices in order to effectively sell these programs.

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Forage in Eastern Oklahoma

Jack Ryan
Oklahoma State University

Southeastern Oklahoma has thousands of acres of abandoned cropland and over-grazed native grasslands that is in a low state of production; bermudagrass and clovers can be grown on much of this land. To increase pasture forage, certain things must be done, the first being a soil test to find out if lime and other nutrients are needed.

This sounds rather basic but I have found that the basics must be stressed to insure successful establishment and production. Lime, phosphorus, potash and nitrogen may all be needed to establish bermuda. One ton of bermuda forage contains about 35-10-45 pounds of NPK respectively. This is definitely not the 10-20-10 ratio of fertilizing that is still so popular.

In addition to soil fertility, the basics of seedbed preparation, sprigging time and rate, varieties for best production, advantages and limitations of legumes with bermuda, and harvesting practices by grazing or mowing each needs to be explained in detail.

The use of tall fescue pastures to compliment bermudagrass is important in southeastern Oklahoma if the labor and expense of keeping a cow is to be reduced.

Summary

Lime the soil if needed. Prepare a good firm seedbed with shallow working tools.

Sprig Midland or Coastal bermuda just before spring growth, or any time during the growing season, until September 1st, after spring growth has replaced food to the roots being used. These roots should be from a clean, well-fertilized planting. Keep the sprigs moist and shaded until planted, and plant as shallow as possible but plant in moist soil. Use a heavy quantity of roots. A complete fertilizer may be applied at sprigging if soil fertility is low. This will increase annual weed and grass competition in the row, but

these can be chemically controlled. New plantings may be grazed after growth is underway. This may reduce competition. Plan application of phosphorus and potash in August or early fall. Seed clovers after the first rains in September. If the bermuda has not made a complete cover by fall, a light disking to level field and drilled to clovers and small grain can give additional grazing. Fescue and ryegrass can be seeded in the fall. Fescue is permanent and will not produce much grazing the first winter. If small grain is planted, additional fertilizer will be needed, especially nitrogen.

Apply nitrogen when growth starts the following spring. Bermuda can use 50 pounds of actual nitrogen every 6 weeks under good growing conditions.

Winter Small Grain for Pasture in South Central Oklahoma

Robert Treadwell
Oklahoma State University

We have been using a small grain mixture plus vetch in southcentral Oklahoma and getting from 300 to 700 pounds of beef per acre. Wheat, rye, and vetch in a mixture of 50, 50, 15 pounds respectively planted before the fifteenth of October, will give us close to 7 months grazing. Stocked at the rate of one to two, 300 to 400 pound animals per acre over a 7-month period, cattle weights can be doubled. This is necessary because of the high cost of production. It takes generous amounts of fertilizer to produce large amounts of this high quality forage. We use the mixtures in order to get forage production over a long period of time. The vetch extends the grazing season 30 to 45 days when the small grain has quit producing very much quality forage.

Soil fertility, cattle health, early planting date, and general good management practices are necessary to make this program work. One farmer in Jefferson County coined the phrase, "The farmers are buying cows and the Cowmen are buying plows." The pasture improvement work has taken place for the most part in old abandoned fields that were growing nothing but Triple awn and winter annual weedy grasses.

Alfalfa

Alfalfa hay yields in Oklahoma average about 2-1/2 tons per acre per year. In southwestern Oklahoma, the yields range from 2 to 6 tons per acre depending upon the fertility program carried on by the farmer and the amount of moisture available for plant growth. Alfalfa could become one of the major cash crops in Oklahoma if acreage were sufficiently increased.

During the past two decades, alfalfa hay yields in Oklahoma have increased less than 0.5 tons per acre. Since present use of fertilizer on alfalfa is very low, use of adequate amounts of fertilizer may be one method of greatly increasing yields.

Fertilizer use is becoming an accepted practice by farmers in southwestern Oklahoma in alfalfa production, but the amounts and ratios for most profitable production have not been determined.

The demands from the livestock industry, feedlots, dairies, and other uses for high quality alfalfa hay have increased the price per ton by an average of eight dollars.

Alfalfa soils in southcentral Oklahoma are very low in phosphorus. Generally, by adding adequate amounts, phosphorus average yields have been increased to 4 tons plus per acre in one of the uniform alfalfa tests in Stephens County, with below average rainfall during test period. Alfalfa seed yields in Oklahoma have been very erratic over the years.

With use of bees and a management system designed to produce seed, some extremely high yields have been produced. A 3-year average of over 600 pounds of number one alfalfa seed per acre has been obtained on one field.

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Tall Wheatgrass, Triticale, Weeping Lovegrass - Their Forage Potential for Northcentral Oklahoma

Dale M. Fain
Oklahoma State University

You have heard about small grains, bermuda, tall fescue, and alfalfa as pasture potentials for Oklahoma. These are certainly some of the best adapted grasses available. However, one limits his potential many times by not considering other species.

Wheatgrass, triticale, and lovegrass acreages have increased the past few years. Producers are finding that these grasses can produce more forage in many cases than the ones more commonly grown. However, each of these species is more limited due to climate and soils.

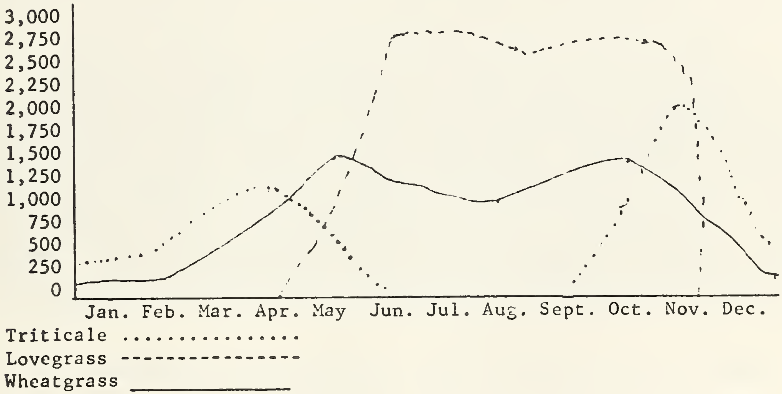
Tall wheatgrass is a cool-season grass that has produced quite well in the northern states for several years. The first wheatgrass in Oklahoma was grown on high pH soils where bermuda or small grains would not grow. However, its definite advantage of a longer growth period has caused many producers to switch even though other forages could be produced. Grazing starts in March and continues until November. Gains per acre have varied but reports of 450 pounds of beef have been made. It is evident that wheatgrass is adapted to a much wider area of the state than first believed and I am sure the acreage of this species will increase.

The Triticales were first producer grown in Oklahoma in 1968. Much publicity created an upsurge in acreage in 1969 and 70. However, less than expected results plus high seed prices has decreased acres substantially in 1971. Triticale produces forage much in the same pattern as rye, but does not possess the winter tolerance. Winter kill has caused many stands to completely disappear and it is common to have only 30-40% survival. Once we market Oklahoma winter tolerant varieties, this species will increase and will compete with rye as a winter forage producer.

Weeping lovegrass acreage in the state has more than tripled in the past 5 years. Up to the early sixties, plantings of this species were very limited due to poor experiences by persons who did not know how to manage the grass. Work at the Southern Great Plains Research Station provided much of this needed management information.

Gains on lovegrass have been tremendous for some people and a sad disappointment for others. The grass grows very rapidly in late April, May, and June. Extreme temperatures and moisture limits production during July and August, but production again increases in the fall until it goes dormant at frost. Recorded gains of 600 plus pounds of beef per acre can be achieved with proper moisture and management

1969--71 FORAGE PRODUCTION
North Central Oklahoma



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Irrigated Brome-Alfalfa Pasture in Northwest Oklahoma

Jim V. Howell
Oklahoma State University

Irrigated cool-season pasture had a rather stormy birth in 1968 with the popularity of circular sprinkler systems. Since that time we have had several failures, funerals, and foreclosures, but still have something over 4,000 acres of pasture being utilized in various ways and degrees of success.

In this area, intensive managed brome-alfalfa pasture will produce more high quality forage than any other crop except alfalfa. Any other grass or legume

added to the mixture will reduce yield and usually lower palatability and quality of the forage.

With proper rotation we can harvest a high percent of the forage with livestock, but clipping and harvesting for hay may be required at certain stages of growth. With intensive management, selling the forage through livestock offers a potential for increased returns.

Rotate, irrigate, and fertilize are the three keys to success or failure with brome-alfalfa pasture. In every case of failure with irrigated pastures, in our area, one or more of these practices were not being properly followed. By dividing the field into four pastures, a 7-day rotation grazing practice can be followed. This allows a 21-day regrowth period between grazing.

Irrigation and fertilization should be scheduled so that 2 3-inch irrigations and 30 pounds of nitrogen can be applied to the root zone during this regrowth period. Irrigated pasture will use about 200 pounds of nitrogen per year or a little over 1 pound per day per acre during the growing season. Water use will vary with growth and weather conditions, but 1/2 to 3/4 inch of water per day can be removed from the root zone during the summer months.

A realistic look at some of the cost involved in irrigation equipment, operation expenses and non-feed cost of livestock will demonstrate why intensive management is essential to the success of an irrigated brome-alfalfa program. A complete irrigation system for 130 acres costs about $35,000. Assuming a 10-year life this gives us about $40.00 per acre per year fixed cost. Normal annual operating cost (fuel, repairs, fertilizer, etc.) average about $56.00 per acre. Add another $10.00 per acre rent or land cost and we have a total of $106.00 per acre annual pasture cost. The non-feed cost or ownership cost of livestock averages about 14¢ per pound of gain. With these cost and average gain on the livestock of 1.25 pounds per head per day, the first 700 to 750 pounds of beef produced per acre will be required just to repay costs or to pay the banker.

Any additional beef produced goes to pay for labor and management.

In summary irrigated brome-alfalfa pasture can be any one of:

A. A profitable enterprise
B. A prestige symbol
C. The reason for a farm sale.

Management determines which one.

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Summary of Extension Forage Crops Program in Mississippi

Hiram D. Palmertree

State College, Mississippi

A recent information sheet distributed by the Mississippi Agricultural and Forestry Experiment Station shows that Mississippi has 74 beef cows per 1,000 acres of land in farms. This is more breeding age beef cows per 1,000 acres of land in farms than any other state in the United States. This information sheet also shows that Mississippi has 27 beef cows per square mile which is surpassed by only one state, Oklahoma, with 31. Three other states also have 27 breeding age beef cows per square mile; Kentucky, Missouri, and Iowa. The number of beef cattle in Mississippi is also expected to increase significantly during the next few years.

At the present time there are approximately 4,000,000 acres of improved permanent pasture in Mississippi. This consists of more than 2,500,000 acres of mixed grass pastures consisting mainly of common bermudagrass and dallisgrass. There are 750,000 acres of bahiagrass located mostly in South Mississippi. Tall fescue comprises approximately 300,000 acres, mostly in North Mississippi. Approximately 1,000,000 of the above listed acreage has a legume growing in combination with the grasses. Mississippi beef producers also utilize 75,000 acres of Coastal bermudagrass, 20,000 acres of temporary summer annuals, and approximately 200,000 acres of temporary winter annuals. Most of this temporary winter grazing acreage is devoted to the grazing of stocker calves during the fall, winter, and spring months.

The Extension Forage Program for beef cattle in Mississippi is divided into two main areas: (1) forages for the cow-calf program and (2) winter grazing for the stocker calf program. Most of our producers are on a year round calving program and are not providing adequate forage when needed to provide good weaning weights on beef calves. The Extension Agronomy Department in Mississippi is working very closely with the Extension Animal Science Department to help provide the forage and cattle management information to increase the calf weaning weights. Several "cow-to-the-acre" demonstrations are being established. These will be used to show the producers how to more effectively use the bahiagrass, tall fescue, and bermudagrass which are now established. Forage councils within the counties are also being organized to stress the value of forages in a beef cattle program.

Most of the calves weaned in Mississippi are light; the state average is approximately 355 pounds. The stocker calf program has been stressed to assist producers in putting more beef on each calf before marketing. Three branch stations in Mississippi each have 20 years' research on grazing calves in winter. Each of these three branch experiment stations have published valuable data and assisted us with getting this information to the producers. During the winter of 1970-71, there were approximately 200,000 calves on winter grazing in Mississippi. Of this total about 130,000 were located in South Mississippi on the Lower Coastal plain and Brown Loam soil areas. However, most sections of the state will support a winter grazing program for these stocker calves, and interest throughout the entire state is increasing. A recent survey indicated that our producers were stocking these temporary winter pastures at the rate of about 1.2 calves per acre.

The average cost of a small grain-ryegrass mixture for winter grazing in Mississippi is approximately $43 per acre. This includes seed, 200 pounds of actual nitrogen, and 65 pounds each of P_2O_5 and K_2O, equipment costs, and average labor costs.

Many of the better producers in Mississippi are netting profits very similar to the published research by our three branch experiment stations doing work on winter grazing. These profits are in the range of $40 to $80 net per acre, depending on the stocking rates and other factors of production.

The two areas of promotion in our Mississippi Extension Forage Program are for cow-calf and grazing of stocker calves. In the future, more emphasis will be placed on forage management systems for the cow-calf program. At the present time our Mississippi cattlemen have approximately 3 acres of pasture per cow and most are weaning a light calf. This ratio will have to be decreased if Mississippi improves its role as being one of the major states in the nation for producing beef.

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East Texas Forage Program

J. N. Pratt
Texas A&M University

The East Texas forage program is based on maximizing acre profits of forage. The foundation for profits is an abundance of high-quality forage used by efficient and productive cattle. The Extension forage program in East Texas is a vital part of the Build East Texas (BET) economic growth program and the statewide "3.76 in '76" Agricultural Income Growth Program.

The basis for an effective educational program is the demonstration technique. Dr. Seaman A. Knapp, the father of Extension, once said, "What a man sees he may doubt, but what a man does he cannot doubt." The Pilot Pasture Demonstration Program has been so-sponsored by the Texas Plant Food Institute. A limited number of "herd unit" demonstrations were established in strategic areas to show maximum profits by combining the best practices for forage production and utilization. Goals for stocking rates were one cow and calf per acre on a 365-day basis. County agricultural agents, program building committees and other leaders have observed techniques for using such a demonstration in their counties. Net incomes of $60 per acre and higher have been realized in the demonstrations.

In 1970, a 4-H Club winter pasture project was initiated in one Extension district. Three-acre pastures were stocked at the rate of two head per acre. Even with unfavorable growing conditions, gains per acre averaged 546 pounds and net income averaged $87.37 per acre.

In addition to the pasture demonstrations, efforts are placed on hay production, forage quality, weed control and other practices for improving profits.

Extension educational meetings include pasture and forage shortcourses, workshops, field days, tours and individual meetings.

The 1-week pasture workshop for county agricultural agents has been of special value. Texas Plant Food Institute has co-sponsored these workshops for 30 agricultural agents for the past 3 years.

Forage quality emphasis includes hay shows and forage testing. The Texas A&M University Forage Testing Laboratory has adopted the Van Soest cell-wall technique for estimating quality components.

PARTIAL SUMMARY OF FORAGE ANALYSES
Texas A&M University Forage Testing Service, 1970-71
A. C. Novosad and J. N. Pratt
Texas Agricultural Extension Service

AGR 4

Type	% Crude protein	% Digestible protein	% Cell walls	Digestible energy*	% T D N	Net energy*
			-- H A Y --			
Alfalfa						
No. samples:	(69)	(69)	(30)	(30)	(30)	(30)
High:	22.9	19.4	62.3	1255	59.7	62.8
Low:	8.7	5.7	29.6	919	46.9	49.0
Average:	17.6	14.3	41.2	1150	55.6	57.1
Bermudas						
No. samples:	(60)	(60)	(16)	(16)	(16)	(16)
High:	19.1	15.7	71.6	1090	53.3	54.5
Low:	2.5	0.0	49.3	902	46.2	45.1
Average:	10.4	6.2	63.5	971	48.8	48.5
Coastal						
No. samples:	(446)	(446)	(110)	(110)	(110)	(110)
High:	18.8	15.4	79.6	1063.	52.3	53.2
Low:	3.6	0.3	52.5	836	47.3	41.8
Average:	9.7	6.8	67.9	939	48.0	47.3
Johnsongrass						
No. samples:	(39)	(39)	(8)	(8)	(8)	(8)
High:	21.0	17.6	64.6	1025	50.9	51.3
Low:	3.4	0.7	57.0	961	47.0	48.1
Average:	7.7	4.8	61.8	986	49.1	49.3

Type	% Crude protein	% Digestible protein	% Cell walls	Digestible energy*	% TDN	Net energy**
Legume-grass						
No.samples:	(25)	(25)	(4)	(4)	(4)	(4)
High:	19.5	16.1	60.2	1133	55.0	56.7
Low:	7.3	4.4	44.1	998	49.9	49.9
Average:	12.7	9.5	52.0	1067	52.5	53.4
Other legumes						
No.samples:	(15)	(15)	(2)	(2)	(2)	(2)
High:	20.4	17.0	40.1	1172	56.5	58.6
Low:	5.3	2.5	39.5	1167	56.3	58.4
Average:	11.5	8.4	39.8	1170	56.4	58.5
Prairie grass						
No.samples:	(34)	(34)	(15)	(15)	(15)	(15)
High:	10.7	7.7	70.5	988	49.8	49.9
Low:	2.2	0.0	61.4	912	47.6	45.6
Average:	5.5	2.7	64.9	958	48.4	47.9
Forage sorghum						
No.samples:	(115)	(115)	(50)	(50)	(50)	(50)
High:	13.0	10.4	68.4	1151	55.3	56.8
Low:	2.1	0.0	42.0	930	47.2	46.5
Average:	6.0	3.1	54.1	1047	51.7	52.4
Hybrid sudans						
No.samples:	(113)	(113)	(41)	(41)	(41)	(41)
High:	23.2	19.7	66.9	1066	52.4	53.3
Low:	3.3	0.6	52.2	942	47.7	47.1
Average:	8.0	5.0	58.1	1016	50.5	50.8
Small grains						
No.samples:	(28)	(28)	(3)	(3)	(3)	(3)
High:	21.6	18.1	74.3	1048	51.7	52.4
Low:	3.2	0.5	54.3	880	45.3	44.0
Average:	10.0	7.0	66.3	947	47.9	47.4

Type	% Crude protein	% Digestible protein	% Cell walls	Digestible energy*	% T D N	Net energy**	% Moisture
			-- S I L A G E --				
Corn							
No. samples:	(24)	(24)	(20)	(20)	(20)	(20)	(24)
High:	5.5	3.5	44.9	680	34.2	34.0	74.1
Low:	2.2	1.1	17.3	259	13.8	13.6	36.8
Average:	3.1	2.1	26.1	392	19.7	19.6	63.9
Sorghum							
No. samples:	(10)	(10)	(8)	(8)	(8)	(8)	(10)
High:	6.2	4.2	36.8	726	35.9	36.5	77.3
Low:	1.8	0.9	15.0	255	12.7	12.7	38.5
Average:	3.8	2.3	25.0	467	23.2	22.2	60.1

*kcal/lb. DM
**mcal/a00lbs. (Therms/a00 lbs.) for maintenance and milk production

# # #

"PILOT"

DEMONSTRATIONS

SHOW

PASTURE PROFIT$

FOREWORD

"What a man hears, he will doubt; what a man sees, he may doubt;
What a man does, he cannot doubt."--Seaman A. Knapp

The above words are the foundation for demonstration work in the Texas Agricultural Extension Service. Dr. Seaman A. Knapp, the father of Cooperative Extension, initiated demonstration work in 1903 in Kaufman County, Texas. This revolutionary method of informal teaching proved that doing and seeing are two of the most effective educational techniques available.

SUMMARY

Pilot Pasture Demonstrations were initiated in 1964 as a cooperative project between the Texas Agricultural Extension Service, the Texas Plant Food Institute and the Tennessee Valley Authority. The Texas Agricultural Limestone Association, county livestock associations and other organizations have also co-sponsored certain demonstrations in specific counties.

The demonstrations have shown that pasture profits can be significantly improved by increasing the quality and quantity of forage and by timely utilization with efficient livestock. Forage producers, professional workers and industry personnel are intensifying efforts in forage production, and farmers throughout Texas' "Forage Belt" are rapidly adopting higher rates of fertilization as their first step in increasing PASTURE PROFIT$.

The purposes of this publication are to:

- report on results of Pilot Pasture Demonstrations
- emphasize important practices for generating greater profits from pastures.

"3.76 in '76"

The "3.76 in '76" slogan is a focused effort to increase agricultural income in Texas from \$2.76 billion to \$3.76 billion by the 1976 crop year. Pastures, hay and other forages will contribute 23 percent of this increase. Plant foods are significant inputs for growing more forage and better quality forage.

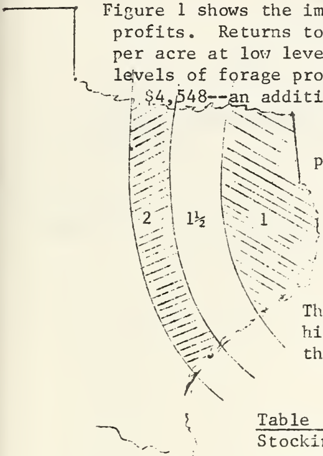
"3.76 in '76"

An *abundance* of high-quality forage is the foundation for cattle *profits*.

Approximately 20 million acres in the "Forage Belt" of Texas are utilized by 3 million head of beef cattle. This is a stocking rate of five to six acres of open pasture per cow.

A beef cow requires approximately 6 tons of forage annually for maintenance and to produce a calf. Most of the area shown on the map can produce sufficient forage on two acres or less annually to support a cow 12 months of the year. In much of the area, forage can be produced on one acre annually to meet and exceed the nutritional requirements of a cow and calf.

Figure 1 shows the importance of high stocking rates for increased forage profits. Returns to investment, labor and management increase from $5.84 per acre at low levels of forage production to $45.48 per acre at high levels of forage production. For 100 acres, profits increase from $584 to $4,548--an additional $3,964 (Table 1).



Annual cow costs are similar at each level of forage production. Fixed costs per acre are similar for each level of forage production. Annual costs--especially fertilizer--are considerably higher at higher stocking rates. Profit increases reault from increased stocking rates and greater calf sales *per acre*.

Forage farming should be the philosophy of cattlemen. This means that major emphasis should be placed on *growing* high-quality forage. Livestock are a means of harvesting the forage grown.

Table 1. Pasture returns at various production levels.

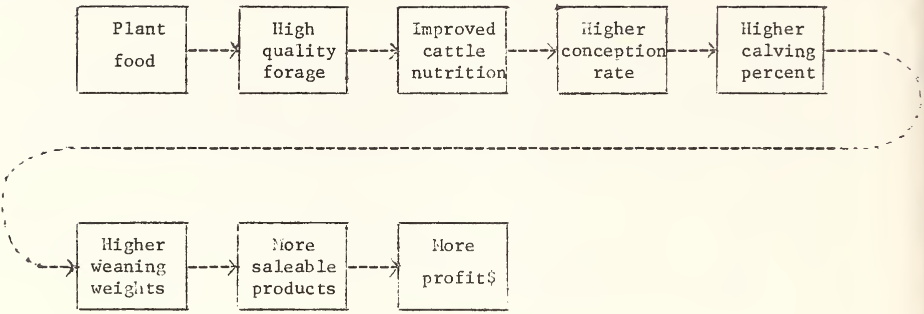
Stocking rate	Return*	Added net return	Added net return/100 A.
1 cow/5 acres	$ 5.84	$ --	$ --
1 cow/2 acres	20.34	14.50	1,450
1 cow/1 acre	45.48	39.64	3,964

*Calf price, $27 cwt.

Such a concept parallels the concept for other crop production. Grain sorghum, rice, and cotton producers aim for high per-acre yields, and harvest when the crop is at an appropriate time and quality.

The following factors are important for high profits from forage farming:

- High dollar volume of sales per acre
  - High forage yields per acre
    - High livestock output per animal
      - High livestock output per acre
        - Efficient use of land, labor and investment.



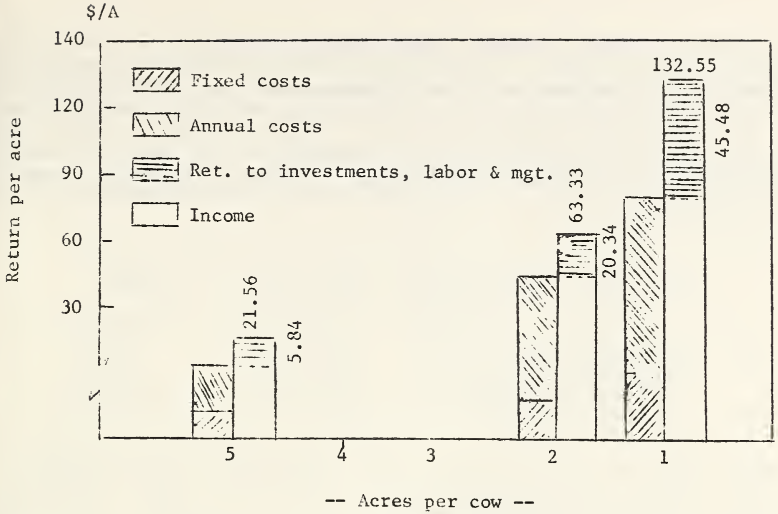


Figure 1. Fixed costs, annual costs and returns of pasture production at various levels of forage production.

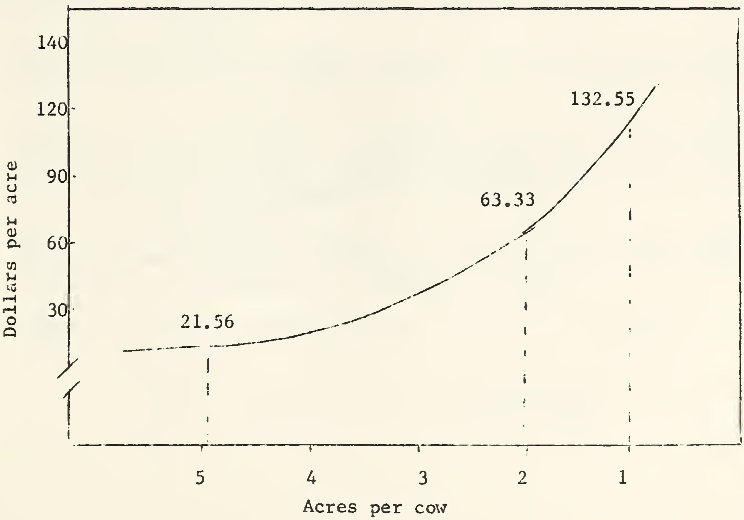


Figure 1a. Fixed costs, annual costs and returns of pasture production at various levels of forage production.

RESULTS OF PILOT PASTURE DEMONSTRATIONS

Each Pilot Pasture Demonstration was established on a 30-acre basis to support a cow herd "unit" at one cow per acre. The "unit" approach permits experience in management to be gained while showing results on a herd-size basis. It also enhances utilization practices of the fertilized area. Improving the soil fertility level was necessary the first year to obtain a stand of high producing, high-quality forage. The limited forage growth during the first year is reflected in lower stocking rates (Figure 2) and lower profits.

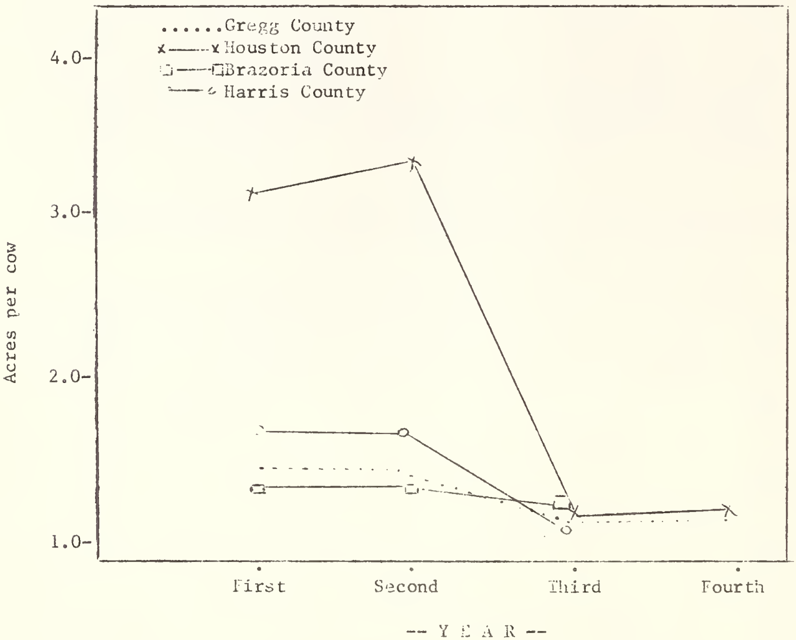


Figure 2. Stocking rate, acres per cow, Pilot Pasture Demonstrations

High rates of fertilizer applications the first few years were necessary to overcome extremely low soil fertility levels (Table 2). Fertilizer rates in Table 2 show the total amounts of nitrogen, phosphorus and potash applied annually, and include topdress applications. Lime was applied at rates recommended by a soil test.

Rates of phosphorus were considerably higher in the first few years than other nutrients. According to thousands of soil samples, most pasture soils are inherently lower in phosphorus than other cropland soils.

Table 2. Fertilizer rates, Pilot Pasture Demonstrations.

County	First year	Second year	Third year
Brazoria	30-150-75	20-80-80	27-80-80
Gregg	30-160-160	95-140-140	50-100-100
Harris	50-175-250	88-160-220	104-103-103
Houston	61-113-133	35-100-160	53-80-80

Profits increased considerably during the second and consecutive years in each demonstration. Prices received for calves generally ranged from $24 to $26 per hundred weight (Figures 3,4,5 and 6). Limited profits the first year resulted principally from low stocking rates. Most of the cattle required 6 to 8 months of high-quality forage to overcome their poor level of nutrition.

Demonstration farmers, county agents, and professional agricultural workers are elated at results. Many benefits have been realized, in addition to increased profits and greater forage production.

- Calving percentage has increased markedly. In most demonstrations, conception rate and calving percentage was 100 percent.

- Calving intervals decreased. Several demonstrations were experiencing calving intervals of 13 to 14 months in the entire herd. Many cows on the 30-acre demonstrations calved within 11 months. Reproduction specialists report that 90 percent of calving difficulty is due to poor nutrition.

- Cattle should have genetic potential for high, efficient production. Inefficient, low producing cattle have no place on highly fertilized pastures. Calf weaning weights should approach 600 pounds or more.

- Livestock management became increasingly simplified in comparison to the more extensive operation.

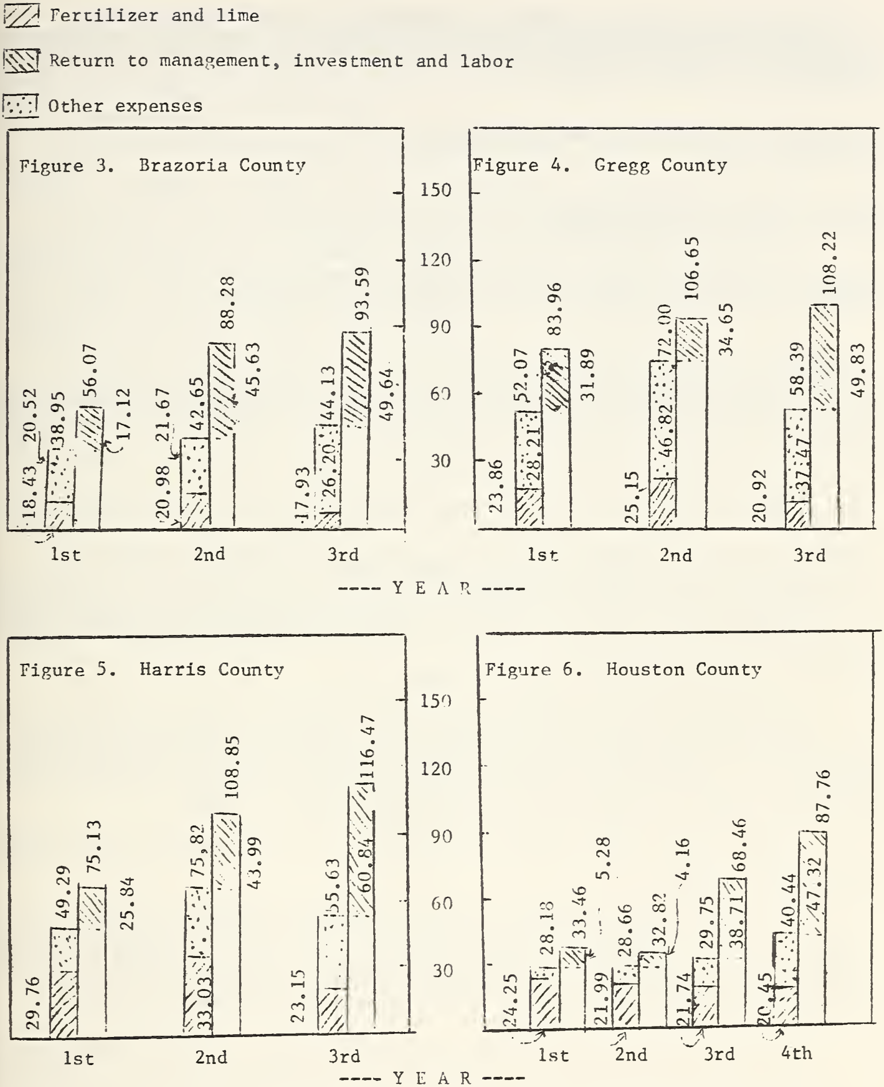
- Animal health was improved. Cattle in the demonstration area showed better hair coats, more thriftiness and more vitality than other cattle on the farms. Internal parasites were less a problem than on unfertilized pastures.

- $25 to $35 per acre throughout the year is a reasonable investment to grow sufficient high-quality forage for one cow for 365 days.

- Forage must be utilized when it is high quality, if cattle gains are to be most profitable. Cross-fencing simplifies grazing when forage is young, leafy and of high quality.

- Fertilized forage grows rapidly and should be grazed heavily. Most grasses--especially bermudagrasses--should be grazed much shorter than when receiving a low level of fertilization.

- Stemmy, low-quality forage should be shredded or mowed to encourage young, leafy growth. Cross-fencing the pastures permits the excess forage to be harvested for hay.



Figures 3, 4, 5 and 6. Expenses and returns, Pilot Pasture Demonstrations.

Pilot Pasture Demonstrations mean more profits for the forage producer. Numerous field days and tours have been held on each demonstration and have shown thousands of forage producers in Texas that pasture profits are generated by using adequate amounts of plant food.

Here are steps for the forage producer to follow for making more profits from pastures:

1. Develop a committment for improving forage quality and production. Develop greater pride in better forage.

2. Develop a long-range plan for pasture improvement and expanding the livestock herd. (If a forage producer lacks the desire or need to expand the livestock program, perhaps little justification exists for intensive production.)

3. Plan the immediate and long-term budget for pasture fertilization and herd expansion.

4. Arrange for immediate and long-term financing for plant food and additional livestock to harvest the increased forage grown.

5. Keep accurate records of items associated with forage and livestock production.

6. Analyze costs and returns regularly and make adjustments for greater profits.

FOR BETTER FORAGE:

7. Obtain a soil test and request fertilizer recommendations for a high stocking rate.

8. Plant high-quality and high-producing species.

9. Use winter forages as the foundation for quality. Clovers and ryegrass can be overseeded in most permanent and warm-season grasses in the Gulf Coast and East Texas areas. Gulf ryegrass can be overseeded in much of the remaining pasture area. Other winter species, such as TAM Wintergreen hardinggrass, can be grown satisfactorily in Central Texas to provide ample quality forage during the winter.

10. Adopt a long-range forage-livestock program of fall calving to utilize high-quality winter forage.

11. Utilize forage efficiently. This means grazing bermudagrass close to the soil surface. Coastal bermudagrass becomes coarse and stemmy and loses palatability when height is more than 4 inches. When pasture species have been adequately fertilized they need to be grazed shorter than when unfertilized. Adequate fertilization improves drouth tolerance, improves quality and hastens regrowth when forage is grazed.

12. Select a small area as the development project. A herd unit area works satisfactorily. This means approximately 30 to 35 acres which should be cross-fenced into three or more comparable size areas. Cross-fencing enhances utilization and provides for harvesting excess forage as hay to conserve quality and production during periods of rapid forage growth.

13. Maintain adequate plant food through frequent topdress applications of fertilizer.

14. Use efficient and productive cattle. Select cows with ability to convert forage into milk. Establish a goal of 600 pounds' weaning weight per calf.

15. Set a goal for high stocking rate. One cow per acre is feasible in much of East Texas and the Gulf Coast. One cow per 1½ to 2 acres is feasible in much of the Blackland and South Central Texas areas.

16. Consult your county agricultural agent for specific recommendations for soil and climatic conditions in your county. He can discuss results of similar pasture demonstrations in the area and supply information on soil testing, fertilizer application, adapted species and other essential information for maximizing forage profit.

Appreciation is expressed to agricultural Extension specialists C. D. Welch, Carl Gray, A. C. Novosad, G. D. Alston, U. D. Thompson, James Long, Tom Prater, James Mallett and J. M. Sprott for their contributions and recommendations for forage production and economic analyses.

Prepared by J. N. Pratt, Agronomist; Texas Agricultural Extension Service
June 1971

Programs for Improved Forage Systems

Joe D. Burns
University of Tennessee

Farmers with successful forage systems usually have quality beef animals or high-producing dairy animals and are able to use land which has a high forage-producing capacity, even though they might be able to make some profit and conserve soil and water on some of the steeper land. Along with high-producing beef and dairy animals and good land, they have a wonderful opportunity to select high-producing plants. But, in some instances, they are not using enough seed, fertilizer and lime except where the seed and fertilizer application equipment is doubling back over the corners in the fields and where the equipment is being emptied just before leaving the field.

Somewhere along the line, it seems that beef cattle producers must take a more positive attitude toward treating pastures as a crop to be managed for high production and profit, and that it is hoped that we in the area of forage production will not discourage them. This is the point where programs for pasture systems may help encourage the beef producer by providing him with a more uniform feed supply and an opportunity to use some of the crops for both hay and pasture.

Let's look at bermudagrass as the base grass in a system and think about some of the program opportunities in getting this plant established. Also, some of the other plants which might be used in combination or succession with bermudagrass.

Bermudagrass has a high production potential with the hybrids, Coastal and Midland, producing more forage than Common, especially at low nitrogen rates, 120 pounds and below, in West Tennessee. Forty samples of common bermuda were taken from old bermuda pastures in West Tennessee and put into small plots at Martin, Tennessee, to determine what kinds of common are already in pastures. Preliminary results show that there are 40 different types ranging from low growing turf types to vigorous types similar to Midland. As of now, we hope to increase Coastal and Midland because they are uniform and high producing.

High quality, weed-free and common free sprigs of Coastal and Midland are now becoming available due to efforts to certify sprig fields which custom operators are using. After 10 years of trying to get Midland and Coastal bermuda acreage increased in Tennessee, the program is beginning to roll due to the fact that custom operators have bought automatic sprigging machines and are charging \$20 to \$30 per acre to furnish the sprigs and plant them. In 1969, we estimate about 500 acres were planted, about 1,000 acres in 1970, and about 2,000 acres in 1971. It doesn't take a mathematician to calculate the gross income from a 2-row sprigger setting 400 acres of grass in 2 months (May and June) at \$30 per acre - that's \$12,000. We have waited for over 20 years for the small 1-acre sprig patches to be spread over whole farms, but it hasn't happened. We believe that it will be done by custom operators.

Weed control is essential the first year and if complete coverage is not obtained, then an application of simazine the second year about the first of March will insure coverage.

Only after a stand is obtained is it suggested that any crop be overseeded on bermudagrass. Many grasses and legumes have successfully been overseeded. Most of the early work in the late '30s showed crimson clover to be superior to the small grains because low nitrogen rates limited the production of the grasses. With 250 to 300 pounds of nitrogen applied to a fescue-Midland bermuda or an annual ryegrass-Midland bermuda combination, the production has been slightly over 5 tons of forage per acre. The distribution of this forage has been most uniform, and we expect to see more acres of this combination for beef cow operations. With Ladino-type white clover added to the mixture of fescue and bermudagrass, we expect to see better grazing utilization of the forage.

Demonstrations in Louisiana and east Texas have shown that a cow and calf can be grazed and enough hay harvested to winter the cow on a single acre. This poses a real challenge to all areas, and it seems that one program in an improved forage system will be bermudagrass plus cool-season plants utilizing high fertility, high-quality cattle and management.

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Forage is Big Business in America

Warren C. Thompson
University of Kentucky

The American Forage Industry, the biggest agricultural business in America, is growing rapidly after several generations of passive concern at least in many areas. At the present time forages in America occupy over 1 billion acres of which 800 million are too rough to cultivate. The other 200 million acres can be cultivated.

The value of the meat and milk sales from forage crops in America is the largest single agricultural income in America. It amounts to $8 billion annually. This amount is equal to the total value of the sales for cotton, soybeans, wheat, tobacco and rice, and is over two times the total value of corn, even though over 80% of the corn crop is fed to livestock.

Forage is money primarily from meat and milk sales, and for the most part it represents the use of land that is not suitable for the production of other crops with a minimum chance to erosion. Eighty percent of the cost of producing beef is feed, and 80% of the feed consumed by beef is forage. Sixty percent of the cost of producing milk is feed, and 80% is forage.

One of the greatest markets for equipment to produce, harvest, and store feed as well as seed, fertilizer, silo's, pesticides, limestone, etc., is forage. Farmers buy $200 million worth of forage machinery annually. This represents about 37% of the total farm equipment sales. Over $250 million are spent for forage seed, or 28% of the annual sales. Likewise, 24% of the fertilizer

sales in America are for forages or $200 million. Farmers annually spend $130 million for silos, $40 million for pesticides, and well over 60% of the expenditures for limestone to modify pH in soils is for the production of forage crops.

There's going to be a tremendous demand on forage production in the 1970's. For by 1980, there must be a 30% increase in meat and milk production if people in America continue to eat meat and drink milk at the same level as today.

The most dramatic and changing area for forage production and use in America is the 14 Mid-South and Southeastern States. By 1980, there will be 21.7 million more beef cattle produced in this area alone. This will represent 46% of the total increase in beef cattle numbers in America. Texas and Oklahoma will be the two leading states in beef production, and they will be followed by Mississippi, Kentucky, Tennessee, Arkansas, Louisiana, Alabama, Georgia, and Florida. Percentage wise, the biggest gainers will likely be in the more humid areas. For the most part, these states are going to produce grass at a faster pace than ever before for the expanding beef herds.

At the present time, 92% of the beef cows in America are in herds of 50 or less. The herds in the future, even though they will increase in size, will still be very modest as compared to the feed yards. It is expected by 1975 that the largest 2,500 feed yards in America will be feeding about 80% of the cattle.

How far and how fast farmers grow in this beef-forage program is primarily up to the key leadership of extension and research working together with a dynamic industry. One of the ways that a program can be solidified is through the American Forage and Grassland Council. Its concern is the same as the independent concern of education, research and industry; 1) to use species and varieties that are adapted, dependable and high-yielding; 2) to establish programs that utilize land, labor and capital to maximize income per acre; and 3) seek out new schemes that will expand the horizons of yield and the development of systems that will give unusual guidance for the future.

To make the AFGC strong demands a dynamic and changing and involved local program, at least at the state level. Many states are now in the process of carrying out their own forage and grasslands programs under the guidance of a State Forage Council. These councils are made up primarily of concerned research, extension, and other agency personnel, along with producers and industry, to serve as a planning group to develop programs and establish priorities for a synchronized forage production and use system. When these many state programs are put together there is a firm foundation for a real action America-wide Forage and Grasslands Program.

The AFGC itself is on the move. We can and we are working diligently at this time to get many things done, but especially we've concerned in about five areas. 1) To provide a medium or a forum through which industry, research, teaching and services can expose programs and products. 2) Keep each other informed of the latest forage-oriented developments so that the total field of research, education and industry can have a united program. 3) Develop

a team effort in selecting topics for publications, symposia and research recommendations; and 4) produce publications and public media items that will tell the whole story to reduce the time lag between the answer to a problem and adoption of a practice.

The AFGC has some immediate plans. A symposium on Forage Fertilization with TVA, the Soil Society of America, and the Crop Society of America at Muscle Shoals, Alabama, in July 1972. This is a symposium that's been needed for many years, and is finally coming into fruitage. The Research Industry Conference with a program built around Modern Forage Practices will be held January 17-18-19, 1972, at Louisville, Kentucky. The release of a comprehensive review on current grassland agriculture in America. The organization of more state and regional councils; four new state councils have already been set in motion this year. Produce at least one publication that is not now available. For instance, there is an immediate need for a publication on small grains for silage. Double-cropping and using both of the crops for silage is another one that is badly needed.

What can we do at the college level to make the American Forage Council more vital and usable in our challenge? It seems to me that we need to 1) become an active member; 2) organize a state forage council if you don't already have one, and get it chartered by the AFGC; 3) help pick up corporate memberships. We have been operating a fantastic program with practically no budget. If we are to provide publications, symposia, meeting, etc., it takes funds; 4) take the leadership in your state and decide to do something beyond your basic interest and move with a total forage program; 5) find people who will help you develop the team approach.

In summary, forages are extremely important to the total economy and environment of our nation. The $8 billion income annual represents less than 20% of our known potential based on our present day technology in much of America. The AFGC, with the expertise of its membership, will continue to contribute to the advancement of forage production and use and through the team approach will make your work more fruitful. This program demands keen leadership to bring about massive change. It is the only organization in America that has the potential to reach into every community, neighborhood, county, and state, to get the leadership to help carry the thrust of a dynamic program. It is only with the team approach that forage in America can provide the meat and milk and the better environment for the present and the future.

*****

Publications --- Georgia Extension Service

W. H. Sell
University of Georgia

1. Bulletins

Bulletins are prepared as reference material for County Agents and some farmer use. These publications are semi-technical written. They usually cover in detail all of the production factors and related facts of a specific crop. Bulletins usually contain pictures, charts, and graphs. Reference bulletins are usually revised every 3 to 5 years. They are usually printed with at least two different colors of ink.

2. Leaflets

Single page leaflets folded several times to a size of approximately 4 x 9 are prepared primarily for County Agent handouts to farmers. Information on production practices is in simple language. Some small simple tables or figures may be used. Leaflets are revised every 1 to 3 years.

3. Mimeograph

Small amounts of new data or some different interpretations of data are prepared and sent to County Agents as reference material. Mimeograph materials are coded and filed according to a standard filing procedure. Many subject matter areas use a specific form of heading for identity of a certain crop.

4. Circular letters

Important, timely facts are sent to County Agents by circular letters. These are often provided as a suggestion for news articles, radio or television programs.

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Trends in Forage Publications for North Carolina

E. Lamar Kimbrough
North Carolina State University

Information on forage crops in North Carolina is presently being published in Extension Circulars, Folders and Leaflets; Experiment Station Bulletins; Crop Research Reports; Farm Magazines; Newsletters and Forage Memos (Agronomy Information Leaflets). Crop Research Reports on variety testing and Forage Memos on specific crops are receiving wide use. No specific recommendations are given in the Crop Research Reports on variety testing. Forage Memos give management practices on fertilization, seeding, harvesting, etc. For information on varieties and pest control reference is generally made to variety test reports and the North Carolina Agricultural Chemicals Manual, respectively. Experiment Station Bulletins which generally appear in the form of long-range summaries are used for basic information. However, the general trend has been fewer bulletins, circulars, etc., and more leaflets and loose-leaf material that can be revised and updated to meet the rapid changing demand of our public.

Note: Leaflet "Location of County Extension Offices in North Carolina" may be obtained from Dr. Kimbrough.

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Trends in Forage Publications

H. W. Wellhausen
University of Arkansas

In 1959 we initiated the preparation of printing of leaflets on each of the major forage species. Contents included adaptation, establishment, maintenance, management and utilization practices.

Our Extension leaflets on the major perennial cool-season grasses include fescue, orchardgrass, and bromegrass. Leaflets on the major perennial warm-season grasses include "Common Bermuda," "Hybrid Bermuda," "Johnsongrass,"and "Dallis and Bahiagrass." Leaflets on annual forage species include "Sudans and Millets," "Winter Cover Crops," Winter Legumes for Pastures," "Oat Production" and "Wheat Production." Other special Extension leaflets include "Alfalfa Production," "Quality Hay Production," "Weed Control in Sprigging Bermuda or Renovation," "Weed Control in Pasture and Hay Crops with Chemicals," "Avoid Nitrate Poisoning," "Pasture and Forage Crops in Arkansas," "Sorghum Production for Grain or Silage," "Silage Production, Storage and Utilization," "Range and Pastures on Clarksville and Nixa Soils," "Corn Production," "Pastures for Sows and Pigs," and "Field Crop Seeding Guide." This is an accumulation of 24 publications since 1959 and at present we have a distribution of approximately 70 to 80 thousand copies annually, which represents about 70 percent of all agronomy publications distributed. Administrative staff has a policy that Extension leaflets be revised every 3 years and Extension circulars be revised every 5 years.

Publication trends may shift to more specific pasture plans by soil and climatic areas of the state to fit specific livestock operations. Studies have already been completed on specific beef cattle enterprises in the upper Arkansas River Valley. These include economic studies of a cow-calf program with either spring or fall calves. Studies also include programs on winter and summer annual forages alone or in combination with perennial species. Carrying capacity by months was programmed by major soil areas with different pasture species with different fertilizer inputs. Similar economic analysis studies are underway for the coastal plains region of the southwestern part of the state.

Last January we initiated a year round pasture educational activity with special emphasis on programming 2/3 of the forage production from fescue and 1/3 from bermuda. Both Grasses would be interseeded with white clover, lespedeza, crimson clover and ryegrass according to soil capabilities and fertility level. Emphasis was also placed on utilization, especially deferred grazing so as to minimize the need for winter hay feeding. The intensive year-round pasture activity was started in seven counties last January and will be extended to eight more counties next January. We hope to develop a publication that will cover the specific phases of the year-round pasture program. This is quite a change from the present leaflets that cover specific grasses and leaving it up to the pasture farmer to put a forage program together to fit his particular soils and livestock needs. This type of approach requires more coordination and cooperation of state staff members. We have all learned that the more people involved the longer it takes to prepare a

publication and final release. By placing emphasis on a few major grasses and legumes with specific plans for production and utilization it should help overcome the frustrations that may be present because of the 34 forage crops and over 100 varieties that we are now recommending. This is a real challenge to our state staff to operate as a team and only emphasize the best practices for more efficient forage production and utilization.

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REGISTRATION LIST - 1971

NAME	STATE	ADDRESS
Anthony, Wilson Brady	Alabama	Auburn
King, Jr., Cooper	"	"
Offutt, Marion S.	Arkansas	Fayetteville
Spooner, A. E.	"	"
Wellhausen, Harry	"	Little Rock
Chapman, H. L. Jr.	Florida	Ona
Johnson, James T.	"	Gainesville
Kretschmer, Jr., Albert E.	"	Fort Pierce
Moore, John E.	"	Gainesville
Mott, G. O.	"	"
Smith, Rex L.	"	"
West, S. H.	"	"
Burton, Glenn W.	Georgia	Tifton
Forbes, Ian, Jr.	"	"
Hanna, Wayne W.	"	"
Langford, W. R.	"	Griffin
Sell, W. H.	"	Hoschton
Harlan, Jack	Illinois	Urbana
Tookey, Harvey L.	"	Peoria
Buckner, Robert C.	Kentucky	Lexington
Jacobson, Don R.	"	"
Little, C. Oran	"	"
Taylor, Timothy H.	"	"
Thompson, Warren C.	"	"
Allen, Marvin	Louisiana	Franklinton
Ellzey, H. D.	"	"
Jones, David L.	"	Shreveport
Mondart, C. L., Jr.	"	Baton Rouge
Monroe, W. E.	"	"
Morgan, N. D.	"	Shreveport
Owen, C. R.	"	Baton Rouge
Gordon, Chester H.	Maryland	Burtonsville
Hyland, Howard L.	"	Beltsville
Leffel, Robert C.	"	Beltsville
Powell, Jerrel B.	"	Beltsville

NAME	STATE	ADDRESS
Bennett, Hugh W.	Mississippi	State College
Burson, Byron L.	"	"
Lusk, John W.	"	Starkville
Palmertree, Hiram D.	"	State College
Thurman, Wesley	"	Poplarville
Ward, Coleman Y.	"	State College
Watson, Vance H.	"	"
Burns, Joseph C.	North Carolina	Cary
Chamblee, Douglas S.	"	Raleigh
Cope, Will A.	"	"
Kimbrough, Everett Lamar	"	"
Lucas, Henry L., Jr.	"	"
Timothy, David H.	"	"
Ahring, Bob	Oklahoma	Stillwater
Banks, Don	"	"
Bates, Richard P.	"	Ardmore
Croy, Lavoy	"	Stillwater
Dalrymple, R. L.	"	Ardmore
Denman, Charles	"	Stillwater
Elwell, Harry M.	"	"
Fain, Dale	"	"
Galeotti, Charles	"	"
Gill, Don	"	"
Graves, Jim	"	"
Greer, Howard	"	"
Griffith, Charles A.	"	Ardmore
Hillier, J. C.	"	Stillwater
Hoehne, Gene	"	"
Horn, Floyd	"	El Reno
Howell, Jim V.	"	Guymon
Huffine, Wayne	"	Stillwater
Johnson, Ronald	"	"
Kiesling, Herman	"	"
Kirby, James	"	"
LeGrand, F. E.	"	"
McCroskey, Jack	"	"
McGehee, Bobby	"	"
McMurphy, W. E.	"	"
Maddox, Fred	"	"
Matlock, Ralph S.	"	"
Murray, Jay	"	"
Nichols, Charles	"	"
Otwell, Kenneth	"	"
Powell, Jeff	"	"
Reed, Lester	"	"

NAME	STATE	ADDRESS
Richardson, Bill	Oklahoma (continued)	Stillwater
Rommann, Loren	"	"
Simmons, Gary D.	"	Ardmore
Steichen, John	"	Perry
Taliaferro, Charles M.	"	Stillwater
Totusek, Robert	"	"
Tucker, Billy B.	"	"
Webb, Bill	"	"
Weibel, D. E.	"	"
Whatley, James	"	"
Arroyo-Aguilu', Jose A.	Puerto Rico	Rio Piedras
Sotomayor-Rios, A.	"	Corozal
Allen, Leonard R.	South Carolina	Clemson
Gibson, Pryce B.	"	"
Barber, William Dean	Tennessee	Knoxville
Barth, Karl M.	"	"
Burns, Joe D.	"	"
Fribourg, H. A.	"	"
Montgomery, Monty J.	"	"
Dalton, Gene	Texas	Plainview
Deterling, Del A.	"	Dallas
Holt, Ethan C.	"	College Station
Kovar, John A.	"	Dallas
Lippke, Hagen	"	Angleton
Novosad, Albert C.	"	College Station
Ott, Bill	"	Overton
Pratt, J. Neal	"	College Station
Riewe, Marvin E.	"	Angleton
Rouquette, F. M.	"	Overton
Taylor, Lincoln H.	Virginia	Blacksburg
White, Harlan E.	"	"
Richards, Clyde R.	Washington, D. C.	